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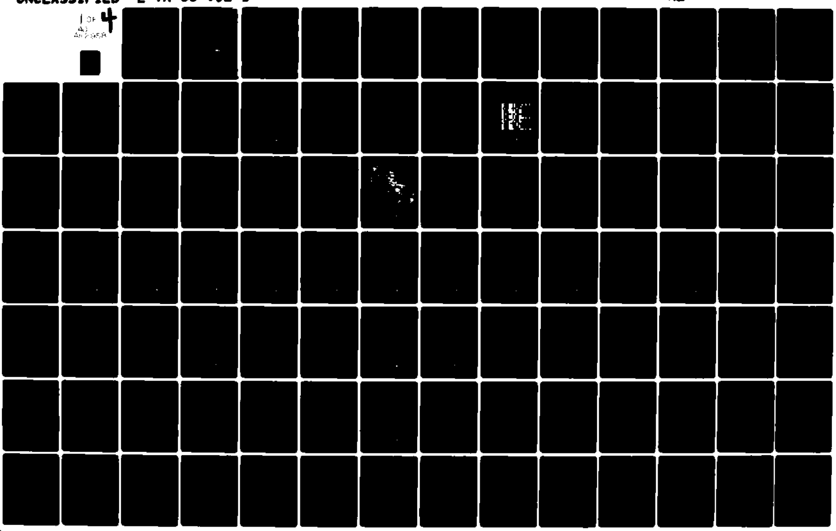

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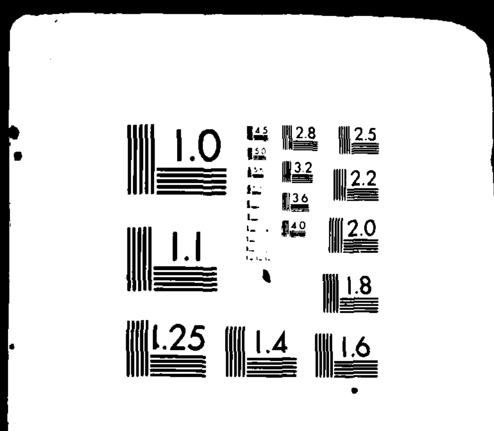

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The preliminary water management planning information in this report represents the integration of over two years of intensive MX water Resources Program activities in the Nevada-Utah siting area.

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MX SITING INVESTIGATION
WATER RESOURCES PROGRAM

PRELIMINARY WATER MANAGEMENT REPORT

VOLUME I

Prepared for:

U. S. Department of the Air Force
Ballistic Missile Office
Norton Air Force Base, California 92409

Prepared by:

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28 September 1981

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FOREWORD

This report was prepared for the Department of the Air Force, Ballistic Missile Office, in compliance with Contract No. F04704-80-C-0006. It presents preliminary water management planning information and recommendations that will aid in MX construction planning and water-supply system design. This report covers 12 deployment area valleys and two Operational Base site valleys that are scheduled for construction in 1982 and 1983 in the Nevada-Utah siting area.

Final water management plans will be developed when all drilling and testing in advance of operational development of the water-supply system has been completed in each valley, water requirements for MX construction have been finalized, and the numerical models of ground-water aquifers, developed by Ertec, have been completed.

The report is contained within two volumes and organized as follows:

Volume I

- The main text providing introductory statements, explanation of results, and recommendations.

- Appendices providing explanation of the criteria and methods used to a) develop the maps delineating suitable water-supply well development areas and b) assign values or scores for matrix appraisal of the water-supply source alternatives and of the additional drilling and testing locations.

Volume II

- The drawings (maps) for the 14 study valleys delineating suitable and excluded areas for water-supply wells, the location of the Air Force water-appropriation application points of diversion, and the recommended location of additional drilling and investigations in advance of operational development of the MX water-supply system.

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EXECUTIVE SUMMARY

INTRODUCTION

The preliminary water management planning information in this report represents the integration of over two years of intensive MX Water Resources Program activities in the Nevada-Utah siting area. Comprehensive water management plans are important to develop for the MX project in order to most efficiently use the water resources of the MX siting area with minimum impact to the local water users, the environment, and the ground-water aquifers.

The purpose of this report is to provide preliminary baseline information and recommendations that will aid in MX water-supply development and well field design and in final water management planning. As the results of numerical models of the ground-water aquifers, being developed by Ertec, become available and MX construction plans and water requirements are finalized, the water management results and recommendations in this report will be updated. This report covers the 12 deployment area and two Operational Base (OB) valleys in which MX construction is scheduled to begin in 1982 or 1983 based on the 17 March 1981 Army Corps of Engineers (COE) water-use schedules. These valleys are:

Cave	Escalante Desert (OB)	Pahroc
Coal	Garden	Pine
Coyote Spring (OB)	Hamlin	Spring
Delamar	Lake	Wah Wah
Dry Lake	Muleshoe	

The preliminary water management planning information presented includes a) recommendations for the preferred water-supply source for each valley, b) delineation of suitable drilling areas for water-supply development, c) description of the general characteristics of the water-supply system alternatives for each valley, d) suggestion of sites for future exploratory drilling and testing in advance of operational development of the water-supply system, e) description of recommended guidelines for hydrologic monitoring site selection and frequency of data collection, and f) suggestions for an approach to water resources impact avoidance and mitigation.

RESULTS AND CONCLUSIONS

Water-Supply Sources

There are four basic sources considered for MX water supply in the Nevada-Utah siting area. These are 1) the appropriation of ground water and the construction of wells in the valley-fill aquifer, 2) the appropriation of ground water and the construction of wells in the regional carbonate aquifer, 3) the lease or purchase of existing surface- or ground-water rights, and 4) the importation of water from "water rich" valleys or sources, such as Railroad, Spring, and Snake valleys and the Colorado River. These water-supply sources were evaluated for each of the 14 study valleys based on legal and physical water availability; potential impacts of withdrawal, cost, and timeliness to develop; and water qual.ty.

Table ES-1 lists the preferred and first alternate water-supply sources that resulted from this evaluation for each of the 14 valleys. Development of the valley-fill aquifer through the appropriation of ground water is the preferred water-supply source in 11 of the 14 valleys. Where ground water from the valley-fill aquifer is legally and physically available, it is usually the least costly and the most timely to develop.

The three valleys in which development of the valley-fill aquifer is not considered the preferred water-supply source are 1) Coyote Spring Valley, 2) Escalante Desert, and 3) Lake Valley. In Coyote Spring Valley, development of the regional carbonate aquifer through the appropriation of ground water is the preferred water-supply source. An Air Force carbonate aquifer test well (13S-63E-23dd, appropriation application number 44220) in this valley has yielded 3400 gallons per minute (gpm) (215 l/s) of ground water during testing. This rate of discharge is equivalent to 5474 acre-ft/yr (6.75 hm^3/yr) if pumped continuously or nearly 60 percent of the peak construction water requirement and 100 percent of the yearly operational requirement for the proposed OB in the valley. Development of the regional carbonate aquifer in Coyote Spring Valley is the least costly of the four options. The potential impacts of its development are presently under evaluation. If significant impacts are projected based on the present field studies, then importation of water would need to be pursued.

PREFERRED AND FIRST ALTERNATE WATER SUPPLY SOURCES

VALLEY	WATER SUPPLY SOURCE			
	VALLEY–FILL AQUIFER	CARBONATE AQUIFER	LEASE/ PURCHASE	IMPORTATION
CAVE	1	2		
COAL	1	2		
COYOTE SPRING (OB)		1		2
DELAMAR	1	2		
DRY LAKE	1	2		
ESCALANTE DESERT (OB)			1	2
GARDEN	1	2		
HAMLIN	1	2		
LAKE	2		1	
MULESHOE	1	2		
PAHROC	1		2	
PINE	1	2		
SPRING	1		2	
WAH WAH	1			2

1. PREFERRED SOURCE OF WATER SUPPLY
2. FIRST ALTERNATIVE SOURCE OF WATER SUPPLY

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WATER–SUPPLY SOURCES
SUMMARY

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TABLE ES-1

For the OB options in the Escalante Desert, the lease or purchase of existing water rights is the preferred water-supply source since the basin has been closed to new ground-water appropriations by the Utah State Engineer. There is, however, an abundance of existing surface- and ground-water rights that could be leased or purchased. This would be far less costly than importation of water from Snake Valley, the nearest "water rich" basin with unappropriated ground water available.

Lake Valley is comprised of two hydrographic basins. Lease or purchase of existing water rights is the preferred water-supply source in the Lake Valley hydrographic basin (northern Lake Valley) because the ground-water perennial yield there is over appropriated. However, development of the valley-fill aquifer is viable in the Patterson Valley hydrographic basin (southern Lake Valley) since unappropriated ground water exists. Development of the valley-fill aquifer through the acquisition of new ground-water rights remains a viable option in both the northern and southern portions of Lake Valley, but the State Engineer may be less likely to approve new appropriations in areas that are presently heavily appropriated.

The first alternative source of water supply is valley-fill aquifer development in one valley, carbonate aquifer development in eight valleys, lease or purchase of existing water rights in two valleys, and importation of water in three valleys. A first alternative source of water supply is important to identify

because the preferred source in a particular valley could become unavailable in part or in total due to unforeseen political, environmental, or legal reasons not considered in this analysis. Also, in some of the 14 valleys, it is possible that a combination of water-supply sources may be used for construction.

Suitable Areas for Water-Supply Well Development

Primary and secondary suitable areas, and excluded areas for MX valley-fill aquifer water-supply well development, have been identified for each of the 14 study valleys based on cultural, hydrogeologic, environmental, and political considerations. Primary areas have a greater probable well yield than the secondary areas because of greater expected saturated thickness of aquifer material or the lack of fine-grained deposits. However, good well yields are possible in secondary areas as verified by Ertec aquifer tests.

Based on this analysis, all of the 14 study valleys have suitable drilling areas for valley-fill aquifer water-supply wells with the exception of Coyote Spring Valley. The results of Ertec testing of a test well at 12S-63E-29 (appropriation application number 43804) indicates that the valley-fill aquifer is not a viable water-supply source for OB construction and operation in that valley. The regional carbonate aquifer has been tested by Ertec and demonstrated to have a high yield capacity in this area.

In Escalante Desert, the water supply would come from the lease or purchase of existing water rights because the State Engineer will not allow new ground-water appropriations in the valley. If existing ground-water rights are leased or purchased, the existing points of diversion could be changed to a location more convenient for an OB water supply. Suitable valley-fill aquifer drilling areas have been identified at or near the Milford and Beryl OB sites.

Water-Supply System Alternatives

The water-supply system alternatives for each of the 14 valleys are summarized in Table ES-2. As indicated in the table, there is an existing Air Force test well, drilled by Ertec as part of the MX Water Resources Program, in 12 of the 14 valleys that can be utilized in the water-supply systems. The only valleys in which drilling and testing have not been conducted are Lake and Pahroc.

In 10 of the 14 valleys, additional development of the valley-fill aquifer and the utilization of an existing Air Force test well is the most viable water-supply system. The 10 valleys are 1) Cave, 2) Coal, 3) Delamar, 4) Dry Lake, 5) Garden, 6) Hamlin, 7) Muleshoe, 8) Pine, 9) Spring, and 10) Wah Wah. In Cave and Spring valleys, no amendment to the Air Force water-appropriation application points of diversion would be necessary to obtain the well yields required during peak MX construction years. Air Force water-appropriation application points of

WATER-SUPPLY SYSTEM AND SOURCE OF MX WATER	ALTERNATIVE I*								ALTERNATIVE II								ALTERNATIVE III							
VALLEY	EXISTING AF WELL	VALLEY-FILL DEVELOPMENT	CARBONATE DEVELOPMENT	LEASE – PURCHASE	IMPORTATION	EARLY STORAGE	AF POD**	AMMEND AF POD**	EXISTING AF WELL	VALLEY-FILL DEVELOPMENT	CARBONATE DEVELOPMENT	LEASE – PURCHASE	IMPORTATION	EARLY STORAGE	AF POD**	AMMEND AF POD**	EXISTING AF WELL	VALLEY-FILL DEVELOPMENT	CARBONATE DEVELOPMENT	LEASE – PURCHASE	IMPORTATION	EARLY STORAGE	AF POD**	AMMEND AF POD**
CAVE	■	■					■	■	■		■						■			■			■	
COAL	■	■					■	■	■		■					■								
COYOTE SPRING	■		■				■	■					■											
DELAMAR	■	■				■	■	■	■		■				■	■								
DRY LAKE	■	■					■	■	■	■	■				■	■								
ESCALANTE	■	■		■					■			■												
GARDEN	■	■					■	■	■		■				■	■								
HAMLIN	■	■					■	■	■		■				■	■	■	■		■			■	
LAKE		■		■						■					■									
MULESHOE	■	■					■	■	■		■				■	■								
PAHROC		■					■						■											
PINE	■	■					■	■	■				■		■									
SPRING	■	■					■	■	■						■									
WAH WAH	■	■					■	■	■	■						■	■	■		■			■	■

* MOST VIABLE ALTERNATIVE

** POD = PENDING AIR FORCE GROUND-WATER APPROPRIATION APPLICATION POINT OF DIVERSION

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SUMMARY OF WATER-SUPPLY SYSTEM ALTERNATIVES AND SOURCES

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diversion in the eight remaining valleys would be used in the water-supply system, but with amendment of some locations. In Delamar Valley, early storage of water in reservoirs is recommended to reduce the quantity of ground water withdrawn by the Air Force during peak years. In all of the 10 valleys, ground water would probably be conveyed by pipelines along roads from the water-supply wells to more strategic water-supply locations along the Designated Transportation Network (DTN) or at the entrance to a cluster road. Existing Air Force ground-water appropriation application points of diversion are utilized for water-supply well locations whenever possible to reduce the number of changes in points of diversion. Such changes would delay the availability of the amended points of diversion for development pending review and possible hearings by the State Engineer.

The four valleys where valley-fill aquifer development is not recommended as the most viable water-supply source are Coyote Spring, Escalante Desert, Lake, and Pahroc. In Coyote Spring Valley, site of the proposed Main Operating Base, the water-supply system would include the utilization of the two existing Air Force carbonate aquifer test wells at 13S-63E-23dd (appropriation application number 44220) and the construction of another carbonate aquifer well to meet peak-year water requirements. This would require a change in the other existing Air Force point of diversion (appropriation applicaton number

43804) at 12S-63E-29da to the location of the new carbonate aquifer well. In Escalante Desert, the water would be leased or purchased from existing owners, the points of diversion moved to a location at or near the OB, and new water-supply wells drilled. In Lake Valley, the most viable alternative is the lease of existing ground-water rights in the northern part of the valley (Lake Valley hydrographic basin). The existing point of diversion of the water owner would be moved to a location along the DTN or at the entrance to a cluster road and a new well drilled that would tap the valley-fill aquifer. In the southern part of Lake Valley (Patterson Valley hydrographic basin), water should be obtained through the appropriation of new ground-water rights and the construction of water-supply wells in the valley fill. In Pahroc Valley, no Air Force test well exists, but the valley-fill aquifer should be developed and the water conveyed by pipeline to more strategic water-supply locations within the valley.

Examples of other less viable water-supply system alternatives in certain areas are:

- o A combination of valley-fill and carbonate aquifer development in Cave, Coal, Dry Lake, and Muleshoe valleys;
- o Importation of water from Pahranagat Valley to Pahroc Valley and the importation of water from the Colorado River to Coyote Spring Valley;
- o A combinaton of valley-fill aquifer development and early storage of water in reservoirs to augment supplies in peak construction years in Delamar Valley; and
- o A combination of lease of existing water rights and development of the valley-fill aquifer in Hamlin Valley.

Additional Investigations

Sites for additional drilling and testing prior to operational development of the water-supply system have been identified. These sites would provide additional information about aquifer properties necessary to develop the ground-water supply and, whenever possible, would provide water-supply wells that are suitable for MX construction use. These sites were selected based on well yield potential, their proximity to a construction plant or camp, DTN, or cluster, the sparseness of aquifer data in the area, and distance from features that could potentially be impacted due to MX ground-water withdrawals.

The additional investigation sites recommended are summarized in Table ES-3. The table shows the Air Force application points of diversion and other recommended sites as well as their general location in primary or secondary drilling areas within the valley. Eighteen sites are recommended for additional investigation among the 14 valleys prior to final well-field design and water-supply system development. Most of the recommended drill sites are in primary areas, but six are in secondary areas because of the absence or unfavorable distribution of primary areas with respect to construction activities. Nine of the 18 drill sites are not existing Air Force points of diversion and will require an application for a change in point of diversion after the Air Force's ground-water right has been established if the wells are to be used as sources of supply.

VALLEY	RECOMMENDED SITES		GENERAL LOCATION *	
	AIR FORCE GROUND WATER APPLICATION NUMBER (Point of Diversion)	OTHER INVESTIGATION SITES (Potential Point of Diversion)	NUMBER OF SITES IN PRIMARY WATER SUPPLY DEVELOPMENT AREA	NUMBER OF SITES IN SECONDARY WATER-SUPPLY DEVELOPMENT AREA
CAVE	0	8N-64E-22cd	1	0
COAL	41707 41708	0	1	1
COYOTE SPRING	0	11S-64E-6a**	0	0
DELAMAR	0	4S-63E-20cd 6S-64E-32ac	2	0
DRY LAKE	0	3N-64E-2ac 2N-64E-36dc	2	0
ESCALANTE DESERT	0	0	0	0
GARDEN	41718	0	1	0
HAMLIN	41721	7N-70E-26ac	2	0
LAKE	41811	0	1	0
MULESHOE	41733	0	1	0
PAHROC	41693	0	1	0
PINE	55021-3	0	0	2
SPRING	0	10N-67E-36bb	0	1
WAH WAH	55019-7	(C-26-14) 4ad	0	2

* PRIMARY AND SECONDARY AREAS FOR MX WATER-SUPPLY WELL CONSTRUCTION ARE BOTH SUITABLE FOR DEVELOPMENT BUT THE FORMER IS BELIEVED TO HAVE GREATER WELL YIELD POTENTIAL. THE CRITERIA FOR DETERMINING PRIMARY, SECONDARY, AND EXCLUDED AREAS FOR WATER-SUPPLY DEVELOPMENT ARE DESCRIBED IN APPENDIX B.

** NUMBERS REFER TO TOWNSHIP, RANGE, AND SECTION NUMBERS; POINTS OF DIVERSION LOCATED IN EXCLUDED AREAS WERE NOT CONSIDERED AS ADDITIONAL DRILLING/TESTING LOCATIONS.

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ADDITIONAL INVESTIGATIONS SUMMARY

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TABLE ES-3

These locations were generally selected because of the need to evaluate valley-fill aquifer well yields and water quality for the proposed construction camps and plants in areas where no Air Force points of diversion were close by. Also, in the case of Dry Lake and Delamar valleys, only one point of diversion had originally been requested for the entire quantity of water required for the peak MX construction year. This was necessitated as a result of the early Ertec drilling and testing activities in these valleys. An application was filed for each test well site in each valley far in advance of the dates of filing of the majority of the other Air Force water appropriation applications for other valleys. In order to maintain the Air Force's priority in time over subsequent applications for water appropriation by other individuals, the full quantity required for MX construction was requested. In this case, only one Air Force test well had been drilled and more information was needed about aquifer properties in other parts of the valleys.

Hydrologic Monitoring Program Criteria and Guidelines

The principal elements of the hydrologic monitoring program include monitoring of ground-water levels, spring discharges, and surface- and ground-water chemistry. Streamflow will also be monitored in certain areas. Where possible, monitoring sites or stations should be located to detect hydrologic changes prior to impact at existing wells or springs.

Monitoring wells should be selected first from suitable private and public wells, especially those monitored by the U.S. Geological Survey and second from new wells constructed after it has been determined that existing suitable wells are unavailable. New wells should be drilled to the minimum depth in the aquifer that corresponds to the mid-point of the screened section of the MX production wells being monitored.

Most of the monitoring wells in all of the valleys should be open to the same aquifer as the MX production wells. However, in valleys with perched aquifers, a monitoring well will be needed in the perched aquifer which could be hydraulically connected with the developed aquifer. Also, there may be valleys in which the regional carbonate aquifer should be monitored when the valley-fill aquifer is tapped or vice versa. Monitoring wells will be needed in such valleys only when there is evidence of hydraulic connection between the two aquifers and when springs are known to be discharging from the regional carbonate aquifer.

A moderate amount of ground-water sampling and a minor amount of surface water and spring sampling will be needed in the MX construction valleys. Special attention is needed if ground water of poor quality is believed to be located within the anticipated range of influence of an MX production well. Pumping at the well could cause the poor quality water to migrate toward the production well. A well for monitoring water quality should be

located between the area of poor quality water and the production well in order to monitor migration.

The frequency of hydrologic monitoring will range from continuous measurement of water-level fluctuations in wells and flow rates in springs and streams at some sites, to a one-time sampling of the quality of water at some wells and springs. Monitoring should be more frequent during the preconstruction and construction phases than during the operational phase.

Impact Avoidance and Mitigation

The two major components of the Air Force program for impact avoidance are the hydrologic monitoring system and the computer numerical models of the valley-fill hydrologic systems.

Data compiled through the hydrologic monitoring program will be used to refine the computer numerical models developed for the individual valleys. The refined models can be used to verify original projections regarding long-term impacts of water withdrawal from Air Force points of ground-water diversion. If the updated projections show impacts which were not originally anticipated, appropriate modifications to the MX water-supply system can be implemented prior to impact occurrence.

If significant or unacceptable impacts to existing water sources (wells, springs, or streams) are projected or do occur for unavoidable reasons, there are several mitigation options available which include the options that follow.

- o Reduction of the rate of water withdrawal at the Air Force point of diversion causing impact;
- o Cessation of water withdrawal at the Air Force point of diversion causing impact; and
- o Delivery of water to the impacted point of diversion to compensate for temporarily reduced production capacity or water quality.

A spring or wetland that has a reduced water level, discharge, or water quality due to MX activities and which harbors threatened or endangered species is more difficult to reconcile. The declines can probably be returned to pre-MX levels through the previously mentioned alteration of pumping patterns. However, the tolerance of endangered species to fluctuations in water levels, food sources, temperature, water quality, and other possible habitat parameters is presently undetermined. The best approach to mitigation of this impact is through a comprehensive hydrologic monitoring program, extrapolation of potential impacts, and implementation of impact-avoidance measures.

1.0 INTRODUCTION

This report presents preliminary water management planning information for 12 deployment area valleys and two Operational Base (OB) valleys in the Nevada-Utah siting area. Final water management plans will be developed when all drilling and testing in advance of operational development of the water-supply system has been completed, water requirements for MX construction have been finalized, and the numerical models of the ground-water aquifers, being developed by Ertec, have been completed. It is intended that this report serve as a model for subsequent water management reports on the remaining MX siting area valleys.

The preliminary water management planning information presented in this report represents the integration of over two years of MX Water Resources Program activities. Water management plans are important for the MX project in order to most efficiently develop and use the water resources of this area. Careful water management planning can minimize the potential impacts to the local water users, the environment, and the ground-water aquifers due to MX ground-water withdrawals. It can also reduce MX system construction costs through identification of suitable water-well development areas and identification of the most efficient water-supply system to satisfy MX water requirements.

1.1 OBJECTIVES AND PURPOSE

The overall objective and purpose of this report, and of the water management program, is to provide preliminary baseline information and recommendations with appropriate documentation

to aid in water-supply development and well field design and in final water management planning. Other more specific objectives and purposes of the water management program are summarized as follows.

- Determine the primary water-supply source and the first alternative source for each valley so that water-supply planning can proceed. The first alternative source of water supply, as well as other alternatives, is important to identify for those instances where the recommended water-supply source cannot be developed or becomes unavailable during construction for various legal, political, or environmental reasons.

- Provide an assessment of the general characteristics of water-supply system alternatives for each valley. This information will aid in a better understanding of which water-supply systems are practical in each valley.

- Delineate the primary and secondary drilling areas for water-supply development based on available hydrogeologic and environmental data and legal considerations. These areas will provide boundaries within which final well field design should be contained in order to minimize impacts to and interference with existing water users and the environment, and it maximizes cost efficiency through development of water-supply sources in the most favorable areas.

- Identify and recommend sites for future drilling and aquifer testing in advance of operational development of the water-supply system to verify suitable aquifer characteristics and provide additional data for water-supply evaluation and final well field design.

- Determine the criteria and guidelines of the hydrologic monitoring program with regards to selection of hydrologic monitoring stations and frequency of monitoring.

- Determine and recommend a general approach to water resources impact avoidance or mitigation.

1.2 SCOPE

The 14 valleys covered in this report are those in which MX construction is scheduled to begin in 1982 or 1983, based on the 17 March 1981 U.S. Army Corps of Engineers (COE) construction

schedules. These are also the valleys for which earliest MX water-appropriation hearings are expected to occur. The location of these valleys is shown in Figure 1-1 and are listed below:

Cave	Escalante Desert	Pahroc
Coal	Garden	Pine
Coyote Spring	Hamlin	Spring
Delamar	Lake	Wah Wah
Dry Lake	Muleshoe	

The scope of the water management program is described below.

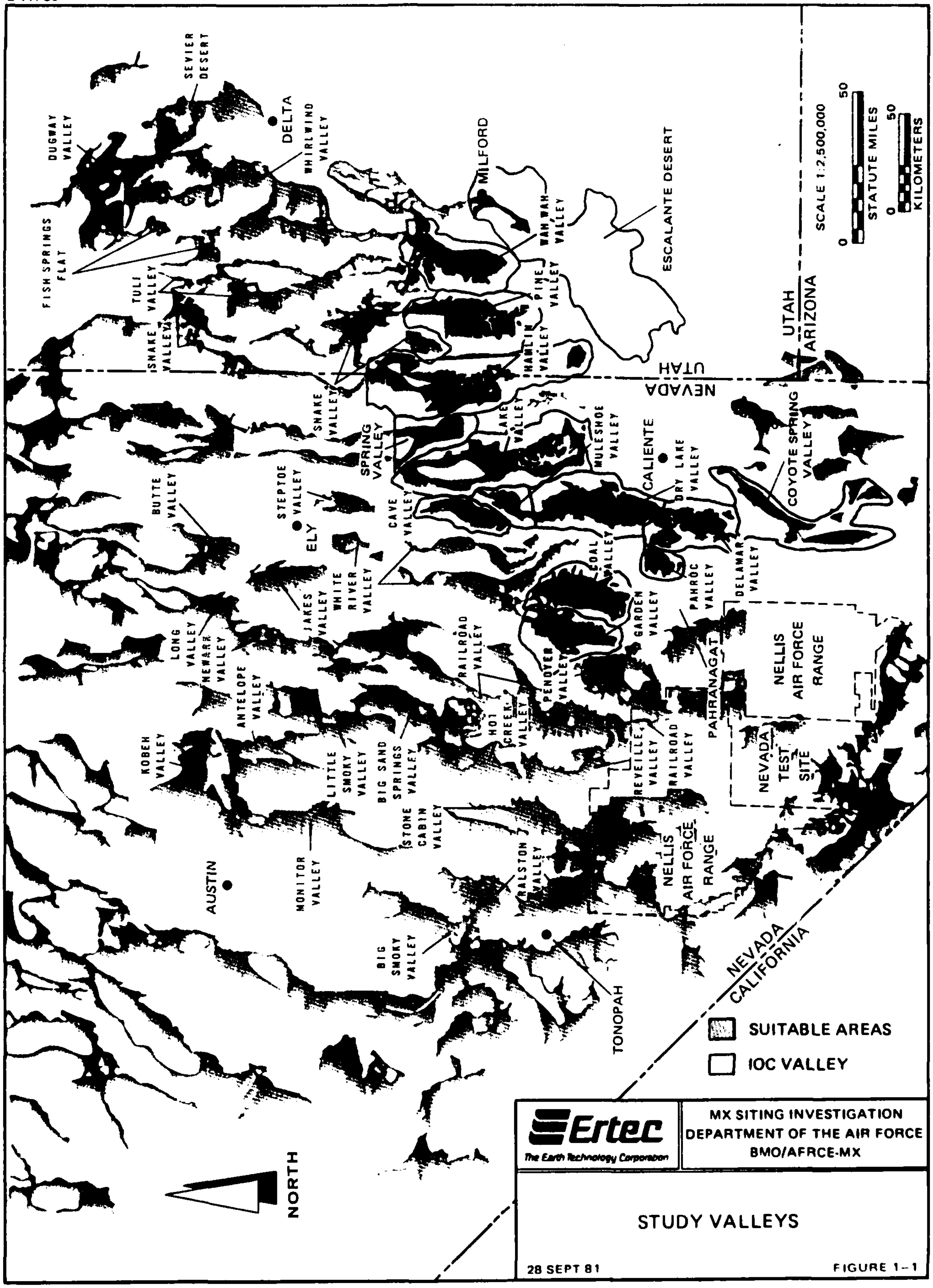
- Assess, for each water-supply source alternative in each valley, the legal availability of water, the possible impacts of MX development on existing water users and the environment, the development potential or physical availability of water, the cost and timeliness of development, and water-quality limitations.

- Compile and integrate all relevant in-house data from previous hydrologic, geologic, and environmental studies including water-rights inventories, industry activity inventories, extensive field hydrologic reconnaissances, drilling and aquifer testing, geophysical surveys, detailed geologic mapping, engineering analyses, and cultural and biological resource assessments to delineate primary and secondary areas for water-supply development and those areas not recommended for water-supply development.

- Assess, for each water appropriations point of diversion, the need for additional drilling and investigation in advance of operational development of the water-supply system. The well yield potential, the proximity to a construction plant, construction camp, cluster, or Designated Transportation Network (DTN), and sparse data areas were evaluated for each point of diversion. In addition to the assessment of the points of diversion, other areas useful for additional data gathering were evaluated based on similar considerations.

- Establish criteria and guidelines for selection of hydrologic monitoring stations through consideration of the features in each valley which could potentially be impacted by MX ground-water withdrawals.

- Identify the potential forms and magnitude of impacts due to MX ground-water withdrawals in the MX siting valleys.



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DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

STUDY VALLEYS

28 SEPT 81

FIGURE 1-1

Evaluate and establish an approach to the implementation of mitigation or impact avoidance measures.

1.3 BACKGROUND

The MX Water Resources Program was initiated in June 1979 for the purpose of evaluating the availability of water for both the construction and operational phases of the MX project in Nevada and Utah and to assess the effects of these withdrawals on local water users, the environment, and the aquifers. As part of the Water Resources Program to date, more than 50 wells have been drilled in the valley-fill and carbonate aquifers, over 45 aquifer (pump) tests have been performed, more than 300 water-chemistry analyses have been completed, and approximately 850 water-level and discharge measurements have been made. The findings of the Water Resources Program have been presented to the Ballistic Missile Office (BMO) in a series of technical, water legal-related, and progress reports. The reports and their general contents are listed below.

Technical Reports

- "MX Siting Investigation, Geotechnical Summary, Water Resources Program FY 79," 21 December 1979. This report included the results of initial field studies in Big Smoky, White River, Dry Lake, Snake, Hamlin, and Tule valleys during FY 79.

- "MX Siting Investigation, Water Resources Program, Summary for Draft Environmental Impact Statement," 15 May 1980 revised 1 August 1980 (FN-TR-38). This report summarized the results of the studies performed to date in 16 valleys in the siting area, including an update of the six previously reported valleys. The additional valleys studied were: 1) Cave, 2) Delamar, 3) Dugway, 4) Fish Springs Flat, 5) Little Smoky, 6) Pine, 7) Railroad, 8) Sevier Desert, 9) Wah Wah, and 10) Whirlwind. It also included a description of the general hydrology, details of the aquifer characteristics, the water-quality limitations of the subject valleys,

and the potential impacts of MX ground-water withdrawals and mitigating measures.

- "MX Siting Investigation, Water Resources Program, Interim Report," 31 October 1980 (FN-TR-40). The Interim Report was an extension of the technical summary report series and included the preliminary results of the investigation of the following valleys: Big Sand Springs, Coal, Garden, Lake, Muleshoe, Pahroc, Penoyer, and Spring. The information presented in the report was similar to that in the Summary for Draft Environmental Impact Statement.

- "MX Siting Investigation, Water Resources Program, Operational Base Studies Report, Volume I, Coyote Spring Operational Base, Nevada," 28 May 1981 (E-TR-52-I). This report presented a discussion of the water resources of the Coyote Spring Valley and results of testing performed to date.

- "MX Siting Investigation, Water Resources Program, Operational Base Studies Report, Volume II, Milford and Beryl Operational Bases, Escalante Valley, Utah," 28 May 1981 (E-TR-51-II). This report had a similar format and content as the Coyote Spring OB report.

Water Legal-Related Reports

- "Overview of Nevada and Utah Water Law: Historical Development and Current Procedures for Rights Acquisition," revised 2 June 1980. This report provided baseline information for and description of the process for obtaining water rights with background on the water law of Nevada and Utah.

- "Municipal Water-Supply and Wastewater-Treatment Facilities in Selected Nevada and Utah Communities," 20 June 1980 (this report was also submitted to BMO as Volume III of the summary report for the Draft Environmental Impact Statement, 15 May 1980). This study was an assessment of the municipalities and towns within and adjacent to the MX siting area and their capacity for increasing their water-supply and wastewater-treatment facilities.

- "MX Siting Investigation, Water Resources Program, Industry Activity Inventory, Nevada-Utah," 2 September 1980. This report provided an assessment of present water use and projected future use by industry and other commercial users.

- "MX Siting Investigation, Water Rights Inventory, Nevada-Utah, Water Resources Program FY 80," 19 December 1980. This report presented a summary of surface- and ground-water rights in the siting area with a breakdown according to applications, permits, certificates, and proofs.

Progress Reports

o "MX Siting Investigations, Water Resources Program, Progress Report," 13 February 1981. The Progress Report presented the status of Water Resources Program activities since the Interim Report of 31 October 1980 through 9 January 1981. It also discussed the preliminary results of field drilling, testing and reconnaissance programs, OB studies, and computer numerical model simulations of valley-fill aquifers in selected valleys.

The results of the Water Resources Program along with the results of Ertec's geology, engineering, geophysics, and shelter and DTN layout activities have also been integrated into the preliminary water management information presented in this report. To enhance the accuracy of the water management program results and conclusions, the most current MX water requirements and cluster and DTN layouts available at the time of this writing have been used. MX water requirements are those developed by the COE and dated 17 March 1981. Cluster and DTN layouts, used in the analyses of water-supply system alternatives and additional drilling and investigation sites, are based on 15 May 1981 Ertec drawings.

The process to acquire the necessary water rights for construction and operation for the MX project began in October 1979 with the filing of a water-appropriation application for Snake Valley in Nevada. In January 1980, applications were filed for water rights in three additional valleys: Dry Lake, Delamar, and White River valleys. These four valleys represent locations in which it was intended to initiate the drilling program, and water rights applications were filed for the planned drill sites.

In July 1980, applications were filed for an additional 25 valleys making a total of 94 water-rights applications in Nevada and Utah. To complete the filing process, applications for the six northern valleys (Kobeh, Butte, Jakes, Long, Newark, and Monitor) and OB sites at Ely, Delta, and Coyote Spring Valley were filed in November and December 1980. The majority of these filings were made in advance of the completion of hydrologic field investigations, Verification studies, and cultural and biological resource assessments which subsequently have provided valuable information for the identification of suitable areas for water-supply well development. As a result, some of the Air Force water-appropriation application points of diversion have been found to occur in presently excluded areas for water-supply well development.

2.0 MX WATER REQUIREMENTS

Water for domestic and construction purposes will be required for the construction of MX missile clusters and support facilities. The estimated MX annual water requirements for each of the 14 study valleys are summarized in Tables 2-1 through 2-14. The water-usage estimates were developed by the COE (17 March 1981) and approved for use in this report by the Air Force. At the time of this writing, these MX water-usage estimates represent the most accurate figures available that have been agreed to by the Air Force, the COE, and other Air Force contractors.

The COE figures are categorized according to type of use and include two basic types of water consumption estimates: 1) unaccompanied estimates which assume that the dependents of construction workers will not be residing at the Life Support Camps (LSCs), and 2) accompanied estimates which assume that the dependents will be housed at the LSCs with the construction workers. The latter assumption (accompanied) results in domestic water consumption estimates 2.5 times those of the unaccompanied estimates. For the analyses performed in this investigation, the accompanied or higher water-use estimates were used for conservation. These estimates for peak-year water usage (maximum quantity required) for each of the 14 valleys is in all cases either less than or equivalent to the quantity of water requested in the Air Force ground-water appropriation applications.

ACTIVITY	82	83	84	85	86	87	88	89	90
1. DOMESTIC									
a. LIFE SUPPORT CAMPS									
b. INDEPENDENT WORKERS		1	2	2	3	1			
2. REVEGETATION		125	345	60	200	180			
3. LANDSCAPING									
4. DUST CONTROL									
a. ROADWAYS		17	115	115	115	21			
b. WORK SITES			34						
c. IN CAMPS	----------	----------	----------	INCLUDED ABOVE	----------	----------	----------	----------	----------
5. ROAD CONSTRUCTION									
a. RECOMPACTION		40	420						
b. CONSTRUCTION ROADS									
c. REGRADING				47					
6. SHELTER EXCAVATION				35	40	5			
7. CONCRETE FOR DDA*									
8. CONCRETE FOR MOB, AOB, DAA & OBTS*									
9. CONCRETE AGGREGATE WASH									
TOTALS (ACRE-FEET / YEAR)		[illegible]	916	259	358	207			

DDA = Designated Deployment Area
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Based on U.S. Army Corps of Engineers (17 March 1981)

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MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

MX WATER—USE
ESTIMATES
CAVE VALLEY, NEVADA

28 SEPT 81

TABLE 2-1

ACTIVITY	82	83	84	85	86	87	88	89	90
DOMESTIC									
LIFE SUPPORT CAMPS		239	660	772	1067	820			
INDEPENDENT WORKERS		1	3	3	4	2			
REVEGETATION		150	575	120	380	318	218		
LANDSCAPING		10	30	33	45	35			
DUST CONTROL									
ROADWAYS		33	165	206	206	104			
WORK SITES		40	95	40	40	40			
IN CAMPS	----------	----------	----------	INCLUDED	ABOVE	----------	----------	----------	----------
ROAD CONSTRUCTION									
RECOMPACTION		125	700						
CONSTRUCTION ROADS		34	17						
REGRADING				78					
SHELTER EXCAVATION*				40	60	30			
CONCRETE FOR*				20	18				
CONCRETE FOR MOB/AOB/ DAA [illegible]*									
CONCRETE AGGREGATE WASH				23	20				
TOTALS (ACRE FEET / YEAR)		632	2245	1335	1840	1349	218		

*

MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Based on U.S. Army Corps of Engineers (17 March 1981)

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DEPARTMENT OF THE AIR FORCE
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MX WATER–USE
ESTIMATES
COAL VALLEY, NEVADA

28 SEPT 81

TABLE 2-2

ACTIVITY	82	83	84	85	86	87	88	89	90
DOMESTIC									
LIFE SUPPORT CAMPS	734	1620	1780	2674	4314	4595	4227	3986	113
INDEPENDENT WORKERS	8	16	18	27	43	46	42	40	2
REVEGETATION		160		100	50	150	197	400	805
LANDSCAPING	31	69	75	413	1183	1195	179	169	5
DUST CONTROL									
ROADWAYS	14	44	44	44	29	14			
WORK SITES	40	290	40	4040	4040	985	40	40	40
IN CAMPS	INCLUDED ABOVE								
ROAD CONSTRUCTION									
RECOMPACTION		125							
CONSTRUCTION ROADS	34								
REGRADING						21			
SHELTER EXCAVATION *									
CONCRETE FOR DDA *									
CONCRETE FOR MOB, AOB, DAA & OBTS *		2	8	22	10	11	8		
CONCRETE AGGREGATE WASH	5	11	31	14	15	11			
TOTALS (ACRE FEET / YEAR)	[illegible]	2343	2010	7322	9685	7025	4685	4635	965

DDA = Designated Deployment Area
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Based on U.S. Army Corps of Engineers (17 March 1981)

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MX WATER–USE
ESTIMATES
COYOTE SPRING VALLEY, NEVADA

28 SEPT 81

TABLE 2-3

ACTIVITY	82	83	84	85	86	87	88	89	90
DOMESTIC									
LIFE SUPPORT CAMPS									
INDEPENDENT WORKERS		1	2	4	4				
REVEGETATION		110	280	175	180				
LANDSCAPING									
DUST CONTROL									
ROADWAYS	21	30	95	95	48				
WORK SITES			22						
IN CAMPS	INCLUDED ABOVE								
ROAD CONSTRUCTION									
RECOMPACTION	95		280						
CONSTRUCTION ROADS									
REGRADING				31					
SHELTER EXCAVATION				35	20				
CONCRETE FOR DDA *									
CONCRETE FOR MOB*, AOB*, DAA *, OBTS *									
CONCRETE AGGREGATE WASH									
TOTALS (ACRE-FEET / YEAR)	116	141	679	340	592				

DDA = Designated Deployment Area
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Based on U.S. Army Corps Of Engineers (17 March 1981)

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MX WATER–USE
ESTIMATES
DELAMAR VALLEY, NEVADA

28 SEPT 81

TABLE 2-4

ACTIVITY	82	83	84	85	86	87	88	89	90
1 DOMESTIC									
A LIFE SUPPORT CAMPS		230	643	874	1050	615			
B INDEPENDENT WORKERS		1	2	4	4				
2 REVEGETATION		115	995	520	698	225			
3 LANDSCAPING [illegible]		21	63	125	106				
4 DUST CONTROL									
A ROADWAYS	37	50	311	311	156				
B WORK SITES		40	278	80	40				
C IN CAMPS	INCLUDED ABOVE								
5 ROAD CONSTRUCTION									
A RECOMPACTION	125		1120						
B CONSTRUCTION ROADS	34		17						
C REGRADING				125					
6 SHELTER EXCAVATION				140	70				
7 CONCRETE FOR [illegible]*			1	23	2				
8 CONCRETE FOR MOB, AOB, DAA *, OBTS *									
9 CONCRETE AGGREGATE WASH			1	26	2				
10 TOTALS (ACRE-FEET / YEAR)	196	457	3486	2278	2170	840			

* [illegible]
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

** [illegible] slightly [illegible] those in Table 4 - 13 due to difference in calculations within the COE MX water requirement document, 17 March 1981

Based on U.S. Army Corps of Engineers (17 March 1981)

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DEPARTMENT OF THE AIR FORCE
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MX WATER–USE
ESTIMATES
DRY LAKE VALLEY, NEVADA

28 SEPT 81 — TABLE 2-6

ACTIVITY	82	83	84	85	86	87	88	89	90
1. DOMESTIC									
a. LIFE SUPPORT CAMPS				2000	2106	2376	2866	2486	
b. INDEPENDENT WORKERS				20	21	24	29	25	
2. REVEGETATION					98	200	218	315	970
3. LANDSCAPING				85	89	101	621	705	
4. DUST CONTROL									
a. ROADWAYS			14	14	14	14	14	14	
b. WORK SITES			250	2040	895	40	40	40	
c. IN CAMPS	INCLUDED ABOVE								
5. ROAD CONSTRUCTION									
a. RECOMPACTION									
b. CONSTRUCTION ROADS		34							
c. REGRADING									
6. SHELTER EXCAVATION									
CONCRETE FOR DDA*									
CONCRETE FOR MOB,AOB,* OBTS* DAA *				16	8	7	6	6	
CONCRETE AGGREGATE WASH				23	11	10	8	8	
TOTALS (ACRE-FEET / YEAR)		34	264	4198	3242	2772	3802	3599	970

* DDA = Designated Deployment Area
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Based on U.S. Army Corps Of Engineers (17 March 1981)

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MX SITING INVESTIGATION
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**MX WATER–USE ESTIMATES
ESCALANTE DESERT, UTAH**

28 SEPT 81

TABLE 2-6

ACTIVITY	82	83	84	85	86	87	88	89	90
DOMESTIC									
LIFE SUPPORT CAMPS									
INDEPENDENT WORKERS		1	3	3	4	2			
REVEGETATION		150	595	100	370	300			
LANDSCAPING									
DUST CONTROL									
ROADWAYS		26	155	196	196	99			
WORK SITES			55						
IN CAMPS	INCLUDED ABOVE								
ROAD CONSTRUCTION									
RECOMPACTION		110	700						
CONSTRUCTION ROADS									
REGRADING				78					
SHELTER EXCAVATION				40	55	35			
CONCRETE FOR DDA									
CONCRETE FOR MOB/AOB/ DAA/OBTS									
CONCRETE AGGREGATE WASH									
TOTALS (ACRE-FEET / YEAR)		287	1508	417	625	436			

DDA = Designated Deployment Area
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Source: U.S. Army Corps of Engineers (1 March 1981)

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MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
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MX WATER–USE ESTIMATES GARDEN VALLEY, NEVADA

28 SEPT 81

TABLE 2-7

ACTIVITY	82	83	84	85	86	87	88	89	90
1 DOMESTIC									
A LIFE SUPPORT CAMPS									
B INDEPENDENT WORKERS		1	3	4	6	2			
2 REVEGETATION		195	995	215	608	275	200	110	
3 LANDSCAPING									
4 DUST CONTROL									
A ROADWAYS		45	306	306	306	52			
B WORK SITES			196	50					
C IN CAMPS	----------	----------	----------	INCLUDED ABOVE	----------	----------	----------	----------	----------
5 ROAD CONSTRUCTION									
A RECOMPACTION		165	1120						
B CONSTRUCTION ROADS									
C REGRADING				125					
6 SHELTER EXCAVATION				95	100	15			
7 CONCRETE FOR DDA *									
8 CONCRETE FOR MOB*, AOB*, DAA & OBTS *									
9 CONCRETE AGGREGATE WASH									
TOTALS (ACRE-FEET / YEAR)		406	2620	795	1020	344	200	110	

DDA = Designated Deployment Area
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Based on U.S. Army Corps Of Engineers (17 March 1981)

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MX WATER–USE ESTIMATES
HAMLIN VALLEY, UTAH AND NEVADA

28 SEPT 81

TABLE 2-8

ACTIVITY	82	83	84	85	86	87	88	89	90
1. DOMESTIC									
A. LIFE SUPPORT CAMPS		45	146	201	273	78			
B. INDEPENDENT WORKERS		1	2	2	3	1			
2. REVEGETATION		115	600	185	453	467			
3. LANDSCAPING (ASC)		8	25	34	46	13			
4. DUST CONTROL									
A. ROADWAYS		46	209	209	209	37			
B. WORK SITES		40	213	70	40	40			
C. IN CAMPS	INCLUDED ABOVE								
5. ROAD CONSTRUCTION									
A. RECOMPACTION		135	700						
B. CONSTRUCTION ROADS		34	17						
C. REGRADING				78					
6. SHELTER EXCAVATION				55	60	15			
7. CONCRETE FOR AS*				23	6				
8. CONCRETE FOR MOB*, AOB*, DAA *, OBTS *									
9. CONCRETE AGGREGATE WASH				27	6				
TOTALS (ACRE-FEET / YEAR)		424	1912	884	1096	651			

MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Table 4-... due to difference in calculations within the COE MX water requirements document, 17 March 1981

Based on U.S. Army Corps of Engineers (17 March 1981)

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
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MX WATER—USE
ESTIMATES
LAKE VALLEY, NEVADA

28 SEPT 81

TABLE 2-9

ACTIVITY	82	83	84	85	86	87	88	89	90
1. DOMESTIC									
A. LIFE SUPPORT CAMPS									
B. INDEPENDENT WORKERS		1	2	2	3	1			
2. REVEGETATION		135	385	70	175	150			
3. LANDSCAPING									
4. DUST CONTROL									
A. ROADWAYS		30	128	128	126	22			
B. WORK SITES			33						
C. IN CAMPS	INCLUDED ABOVE								
5. ROAD CONSTRUCTION									
A. RECOMPACTION		85	420						
B. CONSTRUCTION ROADS									
C. REGRADING				47					
6. SHELTER EXCAVATION				35	35	10			
7. CONCRETE FOR DDA*									
8. CONCRETE FOR MOB,* AOB,* DAA*, OBTS*									
9. CONCRETE AGGREGATE WASH									
TOTALS (ACRE-FEET / YEAR)		251	968	282	341	183			

* DDA = Designated Deployment Area
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Based on U.S. Army Corps Of Engineers (17 March 1981)

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MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
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MX WATER—USE
ESTIMATES
MULESHOE VALLEY, NEVADA

28 SEPT 81

TABLE 2-10

ACTIVITY	82	83	84	85	86	87	88	89	90
1 DOMESTIC									
A LIFE SUPPORT CAMPS									
B INDEPENDENT WORKERS		1	2	4	4				
2 REVEGETATION		105	135	80	75				
3 LANDSCAPING									
4 DUST CONTROL									
A ROADWAYS	15	20	53	53	28				
B. WORK SITES			11						
C IN CAMPS	INCLUDED ABOVE								
5 ROAD CONSTRUCTION									
A. RECOMPACTION	55		140						
B CONSTRUCTION ROADS									
C REGRADING				16					
6 SHELTER EXCAVATION				15	10				
7 CONCRETE FOR DDA*									
8 CONCRETE FOR MOB*, AOB*, DAA*, OBTS*									
9 CONCRETE AGGREGATE WASH									
TOTALS (ACRE-FEET / YEAR)	70	126	341	168	117				

* DDA = Designated Deployment Area
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Based on U S Army Corps Of Engineers (17 March 1981)

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MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

MX WATER–USE
ESTIMATES
PAHROC VALLEY, NEVADA

28 SEPT 81

TABLE 2-11

ACTIVITY	82	83	84	85	86	87	88	89	90
1. DOMESTIC									
A. LIFE SUPPORT CAMPS		180	573	747	1088	260			
B. INDEPENDENT WORKERS		1	3	4	6	2			
2. REVEGETATION		170	575	225	305	507			
3. LANDSCAPING [illegible]		19	61	80	116	28			
4. DUST CONTROL									
A. ROADWAYS		52	215	215	215	37			
B. WORK SITES		40	65	70	40	40			
C. IN CAMPS	INCLUDED ABOVE								
5. ROAD CONSTRUCTION									
A. RECOMPACTION		165	700						
B. CONSTRUCTION ROADS		34	17						
C. REGRADING				78					
6. SHELTER EXCAVATION				55	60	15			
7. CONCRETE FOR [illegible]*				21	8				
8. CONCRETE FOR MOB, AOB, DAA *, OBTS *									
9. CONCRETE AGGREGATE WASH				27	6				
TOTALS (ACRE-FEET / YEAR)		650	2172	1474	1774	872			

* [illegible]

MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Based on U.S. Army Corps Of Engineers (17 March 1981)

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MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

MX WATER-USE
ESTIMATES
PINE VALLEY, UTAH

28 SEPT 81

TABLE 2-12

ACTIVITY	82	83	84	85	86	87	88	89	90
1 DOMESTIC									
A LIFE SUPPORT CAMPS									
B INDEPENDENT WORKERS		1	2	2	3	1			
2 REVEGETATION		60	240	155	140	50			
3 LANDSCAPING									
4 DUST CONTROL									
A ROADWAYS		20	85	85	85	16			
B WORK SITES			22						
C IN CAMPS	-----------------	INCLUDED ABOVE	-----------------						
5 ROAD CONSTRUCTION									
A RECOMPACTION		55	280						
B CONSTRUCTION ROADS									
C REGRADING				31					
6 SHELTER EXCAVATION				25	25	5			
7 CONCRETE FOR DDA *									
8 CONCRETE FOR MOB*, AOB*, DAA *, OBTS *									
9 CONCRETE AGGREGATE WASH									
TOTALS (ACRE-FEET / YEAR)		136	629	298	253	72			

* DDA = Designated Deployment Area
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

Based on U.S. Army Corps Of Engineers (17 March 1981)

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MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

MX WATER—USE ESTIMATES SPRING VALLEY, NEVADA

28 SEPT 81

TABLE 2-13

ACTIVITY	82	83	84	85	86	87	88	89	90
1 DOMESTIC									
A LIFE SUPPORT CAMPS		154	694	743	877	370			
B INDEPENDENT WORKERS		1	2	3	4	1			
2 REVEGETATION		140	940	500	720	238			
3 LANDSCAPING		7	23	31	43	12			
4 DUST CONTROL									
A. ROADWAYS		66	327	327	327				
B WORK SITES		40	226	90	40	40			
C IN CAMPS	----------	----------	----------	INCLUDED ABOVE	----------	----------	----------	----------	----------
5 ROAD CONSTRUCTION									
A RECOMPACTION		215	1120						
B. CONSTRUCTION ROADS		34	17						
C. REGRADING				125					
6 SHELTER EXCAVATION				100	110				
CONCRETE FOR DDA *				21	4				
8 CONCRETE FOR MOB,* AOB,* DAA *, OBTS *									
CONCRETE AGGREGATE WASH				24	4				
TOTALS (ACRE-FEET / YEAR)		657	3194	1954	2264	661 **			

*DDA = Designated Deployment Area
MOB = Main Operational Base
AOB = Alternate Operational Base
OBTS = Operational Base Test Site
DAA = Designated Assembly Area

** [illegible] than that in table 4 due to difference in calculations within in the COE MX water requirements document 17 March 1981

Based on U.S. Army Corps Of Engineers (17 March 1981)

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MX WATER–USE
ESTIMATES
WAH WAH VALLEY, UTAH

28 SEPT 81

TABLE 2-14

2.1 DOMESTIC WATER USE

2.1.1 Life Support Camps

Based on the COE water-usage scenario, LSCs will be used to provide housing for construction personnel in five of the 12 deployment area valleys and at both Main Operating Base (MOB) and Alternate Operating Base (AOB) sites. The accompanied maximum populations for the LSCs in the deployment area valleys range from 5632 in Wah Wah Valley to 6560 in Dry Lake Valley. This includes consideration of those also planned for Coal, Lake, and Pine valleys. The maximum accompanied populations at the LSCs for the MOB and AOB sites are estimated to be 25,670 and 15,982, respectively. A water-usage rate of 200 gallons (757 l) per capita per day and a water-use period of 365 days per year were used.

2.1.2 Independently Housed Workers

It was assumed by the COE in the estimation of MX water demands that 10 percent of the total MX construction force will consist of day workers and transient personnel who, although not residing in LSCs, will require additional limited water supplies. A water-usage rate of 50 gallons (189 l) per capita per day and a water-use period of 250 days per year were used as base assumptions in developing the COE estimates.

2.2 CONSTRUCTION WATER USE

2.2.1 Revegetation

Water will be required for the revegetation of disturbed areas during and after construction. It is assumed here that irrigation will be used during revegetation. Corps of Engineers

estimates of the demand for water for revegetation are total requirements to promote revegetation and are based upon the following assumptions.

- 5 acre-feet (0.0006 hm^3) per shelter or 115 acre-feet (0.14 hm^3) per cluster will be required for revegetation;
- 4.04 acre-ft/mi (0.008 hm^3/km) will be required for revegetation along the DTN;
- 125 acre-feet (0.15 hm^3) per cluster will be required for revegetation along cluster roads;
- A total of 7460 acre-feet (9.20 hm^3) will be required for revegetation of support roads;
- The water requirement in acre-feet for revegetation of LSCs is 0.01530 times the maximum estimated population of the LSC;
- 107 acre-feet (0.13 hm^3) will be required for revegetation at each precast concrete plant site;
- 443 acre-ft/yr (0.53 hm^3/yr) will be required for revegetation at each marshalling yard;
- 200 acre-ft/yr (0.25 hm^3/yr) will be required for revegetation at each construction support yard;
- A total of 2450 acre-feet (3.02 hm^3) will be required for revegetation material source sites including processing plants; and
- 300 acre-feet (0.37 hm^3) will be required for revegetation along railroads.

2.2.2 Dust Control

Water will be required throughout the construction period for dust control. The COE estimates of the water demand for dust control are based on the assumptions that the entire roadbed and shoulders will be treated with an asphalt emulsion and a twice-weekly application rate will be used. Based upon an application rate of 0.25 gal/yd^2 (1.13 l/m^2) per application

for operational and construction access roads, the COE has estimated that 32.6 acre-feet (0.04 hm^3) per cluster per year will be required for operational roads and 7 acre-ft/yr (0.01 hm^3/yr) will be required for construction access roads. Dust control along the DTN will use an equal mixture of 0.125 gal/yd^2 (0.566 l/m^2) of water and 0.125 gal/yd^2 (0.566 l/m^2) of asphalt. The DTN water demand for dust control is estimated by the COE to total 0.8 acre-ft/mi (0.002 hm^3/km) per year.

2.2.3 Road Construction

The COE estimated water demand for road construction is based upon a rate of 15.667 acre-feet (0.02 hm^3) per cluster of which 3.267 acre-feet (0.004 hm^3) is for recompaction of DTN and 12.4 acre-feet (0.015 hm^3) is for recompaction and regrading of construction roads.

2.2.4 Shelter Excavation

The water demand for shelter excavation is based upon a COE estimated requirement of 26 acre-feet (0.03 hm^3) per cluster.

2.2.5 Concrete

Water will be required for concrete for shelters, resident operational support equipment enclosures, transformer vaults, electrical manholes, and floor slabs and foundations for facilities at the proposed Area Support Center (ASC) in Dry Lake Valley. For cluster shelters, enclosures, vaults, and manholes, an assumed rate of 2.2 acre-feet (0.003 hm^3) per cluster was used in the COE estimates. For the ASC, the total estimated water requirement is only 0.5 acre-feet (0.001 hm^3).

2.2.6 Concrete Aggregate Wash Water

Water will be required to wash aggregate prior to concrete mixing. The COE estimates are based upon a water requirement of 2.5 acre-feet (0.003 hm^3) per cluster. In addition, an estimated 0.7 acre-feet (0.001 hm^3) will be required for aggregate wash water at the ASC in Dry Lake Valley.

3.0 WATER-SUPPLY ALTERNATIVES

3.1 INTRODUCTION

The alternative water-supply sources for MX construction and operation that are considered are:

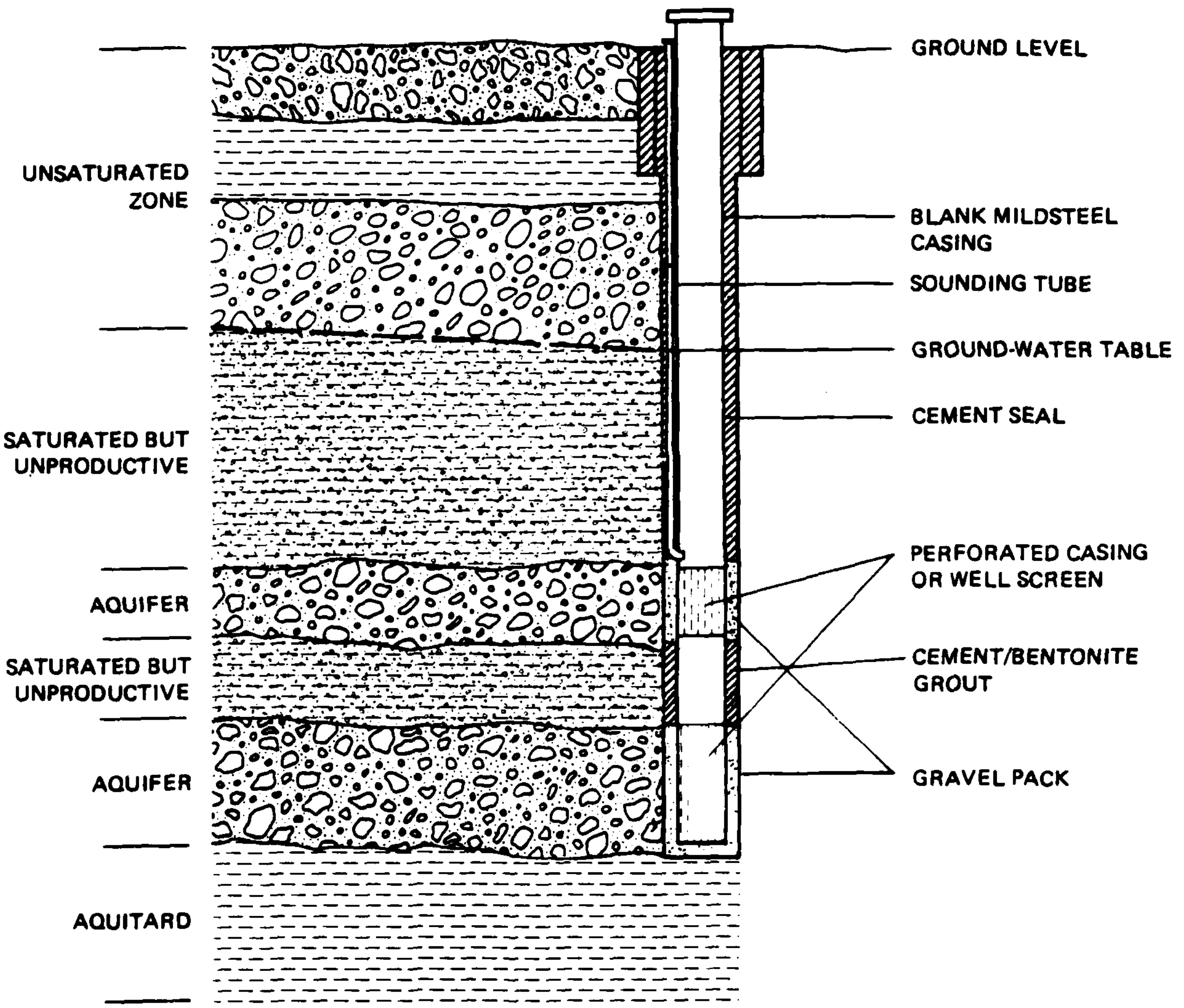
- o The appropriation of ground-water rights and the construction of water wells in the valley-fill aquifers;
- o The appropriation of ground-water rights and the construction of water wells in the regional carbonate aquifers;
- o The lease or purchase of existing surface-water and/or ground-water rights; and
- o The importation of water via pipeline from "water-rich" valleys to those valleys where water supplies are insufficient.

The relative merits of each alternative vary according to the hydrologic characteristics and MX water requirements in each siting valley. A matrix analysis was used to provide a structured process for evaluating the applicability of each alternative to a given valley and determining which should be developed as the primary source. A detailed discussion of the matrix methodology is presented in Appendix A. Each of the alternatives and its advantages and disadvantages are discussed below.

3.2 VALLEY-FILL AQUIFER DEVELOPMENT

3.2.1 Water-Supply Well Design and Construction

Based upon the analysis of the hydrologic conditions in each of the MX siting valleys, it appears that, in most valleys, there are sufficient quantities of unappropriated ground water available from the valley-fill aquifer to meet MX demands. This supply may be best developed through the construction of conventional water wells as schematically shown in Figure 3-1.



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SCHEMATIC DESIGN OF MX VALLEY–FILL WATER – SUPPLY WELL

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FIGURE 3-1

The depth and diameter of MX wells will vary according to the depths to ground water and the aquifer. Within the deployment area, the depth to ground water ranges from less than 10 feet (3 m) below land surface to over 800 feet (244 m). The depth to productive water-bearing zones, however, may be substantially greater. MX water-supply wells, as discussed for each of the study valleys in Sections 4.1.3 through 4.14.3, will likely range in depth from 500 feet (152 m) in valleys with shallow ground water to 1300 feet (396 m) in valleys with deeper aquifers.

Anticipated diameters for boreholes and well casing range from 16- to 24-inch (41- to 61-cm) diameter borings cased with 10- to 16-inch (25- to 41-cm) ID well casing. Exploratory drilling conducted by Ertec in 12 of the 14 study valleys show that test wells constructed with 16-inch (41-cm) boreholes and 10-inch (25-cm) ID casings are capable of supplying constant discharge rates of 75 to 740 gpm (5 to 47 l/s). With larger diameter cased production wells, increased well yields may be expected. The primary function of a larger diameter well would be accommodate a larger pump.

3.2.2 General Valley-Fill Aquifer Characteristics

The ability of aquifers to store and transmit water is a very important consideration in the selection of sites for MX water-supply wells. As suggested in Figure 3-1, not all sediments below the water table are favorable aquifers. Typically, the valley sediments in the study valleys consist of interbedded

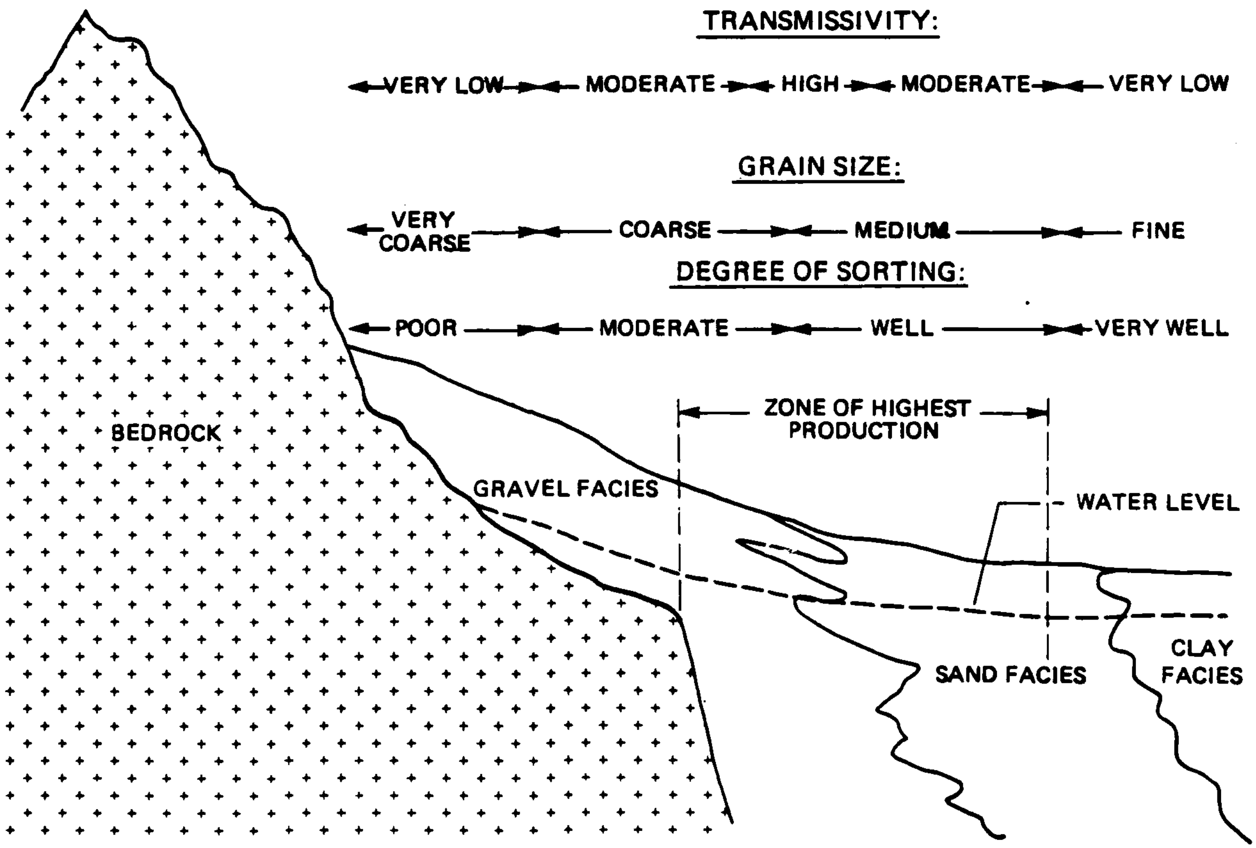
sequences and mixtures of gravel, sand, silt, and clay. There is commonly a gradation from coarse-grained and poorly sorted sediments adjacent to the mountain front to fine-grained, well-sorted sediments in the playa areas usually near the center of the valleys (Figure 3-2). The preliminary results of aquifer tests conducted throughout the deployment area indicate that the ability of the aquifer to transmit water (transmissivities) within the study valleys is usually low in the area within about 1 mile (1.6 km) of the mountain front. This is presumably due to a combination of poor sorting and limited saturated thickness. Transmissivities increase toward the valley axis, reaching a maximum value near the foot of the alluvial fans and decreasing as the percentage of clay increases toward the playa areas. By locating MX water-supply wells in higher transmissivity zones, larger well yields may be obtained.

3.2.3 Impacts

During withdrawals, MX water-supply wells will lower ground-water levels in the vicinity of the well. The amount of lowering or drawdown which occurs is a function of the aquifer properties, the well design (efficiency), the volume of water pumped, and the duration of the pumping period. The conceptual cone of depression which will occur around MX water-supply wells is shown in Figure 3-3. Based upon the preliminary results of aquifer tests conducted and finite difference numerical ground-water flow modeling of the valley-fill aquifers in the study valleys, water-level declines of 1 to 5 feet (0.3 to 1.5 m) are projected to occur at a distance of 1 mile (1.6 km) from MX

CONCEPTUAL CROSS SECTION THROUGH REPRESENTATIVE MX VALLEY

AQUIFER TRANSMISSIVITY, GRAIN SIZE, AND SORTING ALL VARY WITH DISTANCE FROM THE MOUNTAIN FRONT.



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CONCEPTUAL DISTRIBUTION OF GRAIN SIZE, SORTING, AND TRANSMISSIVITY FOR A TYPICAL MX DEPLOYMENT VALLEY

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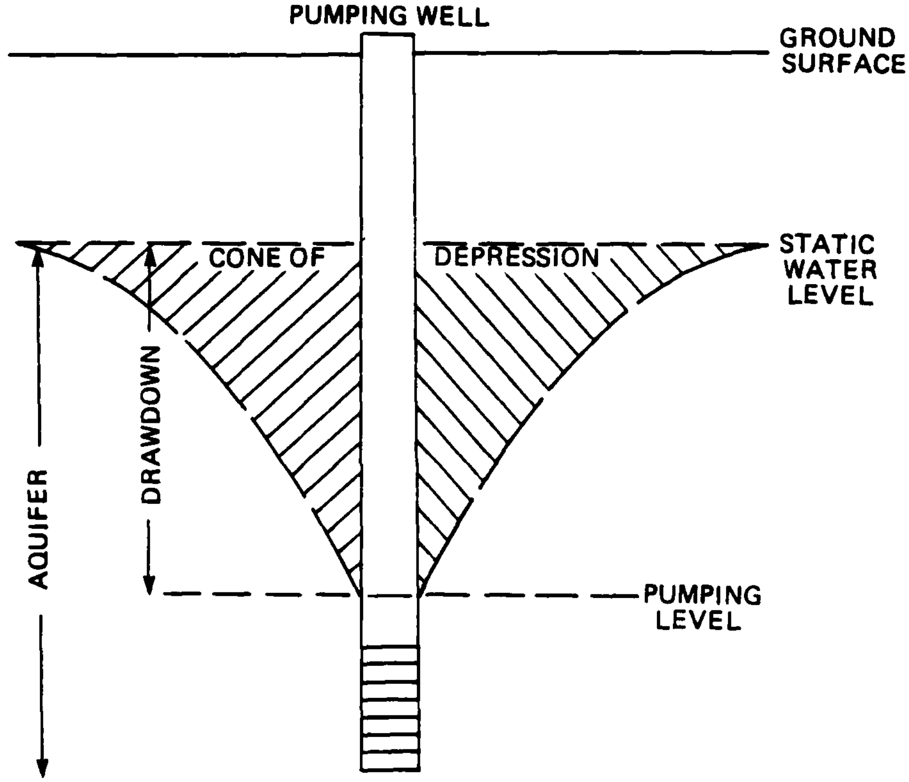
FIGURE 3-2



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CONE OF DEPRESSION (WATER–LEVEL DRAWDOWN) AROUND AN MX WATER–SUPPLY WELL

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FIGURE 3-3

water-supply wells after two years of continuous pumpage at required rates. At a distance of 3 miles (5 km), no water-level drawdowns are expected to occur. These results are for for those valleys that are believed to have generally unconfined aquifer conditions based on available lithologic logs. Those valleys are Coal, Delamar, Dry Lake, Garden, Hamlin, Escalante Desert, Pine, Spring, and Wah Wah. Cave Valley may have generally confined to semiconfined aquifer conditions based on drillers' logs, and water-level declines may be greater than those indicated for unconfined aquifer conditions. Pahroc, Muleshoe, Lake, and Coyote Spring valleys are expected to have generally unconfined aquifers but actual conditions are still undefined at present. By maintaining setback distances of at least 1 mile (1.6 km) from all existing water wells, the effects of drawdown from pumping MX wells upon other wells can be minimized.

Similarly, MX well setbacks from springs can also minimize impacts on spring discharge rates. If MX water-supply wells are located too close to springs, a reduction in the discharge rate of the spring could occur. In several of the valleys, springs occur which are believed, on the basis of water chemistry, temperature, discharge, and hydrologic environment, to be discharging ground water from regional carbonate aquifers which commonly underlie the valley-fill sediments and hydraulically connect many of the valleys. These springs are valuable sources of water for present water users and also provide habitat for a number of aquatic plant and animal species in some instances.

The impact of MX valley-fill water wells upon these springs is dependent upon the degree of hydraulic connection between the valley-fill, the regional aquifer, and the spring itself. To be conservative, it is recommended that MX water-supply wells be located greater than 3 miles (5 km) from a known or possible regional spring. The regional and possible regional springs identified to date within the study valleys are listed in Table 3-1.

Potential water-level declines around local valley-fill aquifer springs due to MX ground-water withdrawals will be the same as those described for wells in the valley-fill aquifers. Similarly, MX well setback distances from local springs should be at least 1 mile (1.6 km). However, this setback distance should be reevaluated as well field design and pumping rates are finalized and completed numerical models are available for evaluating the resultant distance-drawdown effects.

3.2.4 Water Distribution System

Due to the high costs of water well construction, the uneven distribution of suitable drilling locations, or legal constraints, it may not be practical to construct water-supply wells for each cluster. Water for construction purposes may have to be transported several miles from a supply well to the place of use. Temporary pipelines to transport the water from the supply wells to central distribution points, or reservoirs, along the DTN near cluster entrance roads may be necessary in some cases. Water trucks could then be used to distribute the water to the actual construction sites.

LOCATION	NAME	DISCHARGE (gpm)	TEMPERATURE (°C)	CHEMICAL CLASSIFICATION[5]	STATUS
Coyote Spring (OB)					
14S/65-9ccc	Baldwin House Spring South	[2] 54	[2] 33	Regional	Possible Regional *
14/65-9ccc	Baldwin House Spring North	[2] 103	[2] 33	Regional	Regional
14S/65-15ccc	Iverson Spring	–	[2] 33	Regional	Regional
14S/65-16adb	Muddy (Big) Spring	[2] 3200	[2] 33	Regional	Regional
14S/65-16bca	Baldwin Cut Spring	[2] 242	[2] 33	Regional	Regional
14S/65-16db	Jones Spring	[2] 853	[2] 33	Regional	Regional
14S/65-16ddc	Pederson/Warm Spring	[2] 220E	[2] 32	Regional	Regional
14S/65-17aa	Lewis Spring	15			Possible Regional *
14S/65-21aa	Iverson (Warm) Spring	[4] 1700	32	Regional	Regional
Dry Lake Valley					
3/65-31cc	–	3	24	Regional/Local	Possible Regional *
Hamlin Valley					
5/70-11daa	–	100E	16	Regional	Possible Regional *
Lake Valley					
9/65-4c	Geyser Spring	[1] 200 - 225 * *	[1] 20	Small Local	Possible Regional *
Wah Wah Valley					
(C-27-15) 11aba	Wah Wah Spring	[4] 450E	[4] 20	Regional	Regional

* Possible Regional Spring - Does not meet all criteria
* * Range of discharge measurements
E Estimated discharge
Ertec measurements unless otherwise noted.

REFERENCES

1. Rush and Eakin, 1963
2. Bateman, 1976
3. Stephens, 1974
4. Hess and Mifflin, 1978
5. Mifflin, 1968

CRITERIA FOR CLASSIFICATION OF REGIONAL AND POSSIBLE REGIONAL SPRINGS

Chemical characterization diagrams, temperature, and spring discharge data have been used to determine whether a spring is discharging from a local or a regional source. A regional spring in this report is defined on the basis of the following criteria:

1) The water temperature is 18°C or greater. This is approximately 10° above the average air temperature for the MX deployment valleys. Regional springs should be warmer than the average air temperature because they discharge waters which are assumed to circulate deep within the earth's crust and gain heat.
2) The discharge is 100 gpm or greater. A regional spring should have a large discharge because of the large amounts of water available in the carbonate aquifers and suitable hydraulic conditions for rapid movement.
3) Chemical characterization diagrams show a regional source.

A spring is classified as possible regional if it satisfies only two of the above criteria.

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REGIONAL AND POSSIBLE REGIONAL SPRINGS IN THE STUDY VALLEYS

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TABLE 3-1

To reduce the number of MX water-supply wells required and to ensure that peak-water demand can be satisfied, it may be desirable to construct storage reservoirs. In som. valleys where well yields are expected to be low, it is recommended that storage reservoirs be considered. These reservoirs could be constructed at least one year prior to the initiation of MX construction activities. Such reservoirs could be filled with ground water prior to actual need, thus reducing the number of supply wells needed and the peak-year water withdrawals in some valleys. Storage reservoirs would need to be large enough to store adequate volumes of water during times of peak demand. The high evaporation rate in the valleys and the leakage rate of the mat rials used in the construction of the reservoir are important parameters in the design of such storage facilities.

The costs of the storage of ground water in surface reservoirs prior to actual use is significant. The reduced costs in well construction, however, would tend to offset some of the costs of storage. The construction of clay coffer dikes in playa areas is a low-cost-storage method but requires reclamation of areas disturbed for borrow pits and dike reclamation upon abandonment. It may be possible to use inflatable dikes similar to those used as temporary flood-control structures. Such structures could be placed in shallow trenches in playa areas. Although expensive, these dikes could eliminate costly reclamation work and could be used in other siting valleys upon completion of construction activities in the area. An application for the appropriation

of surface water in playas would likely have to be filed should water accumulate naturally in these areas from surface runoff.

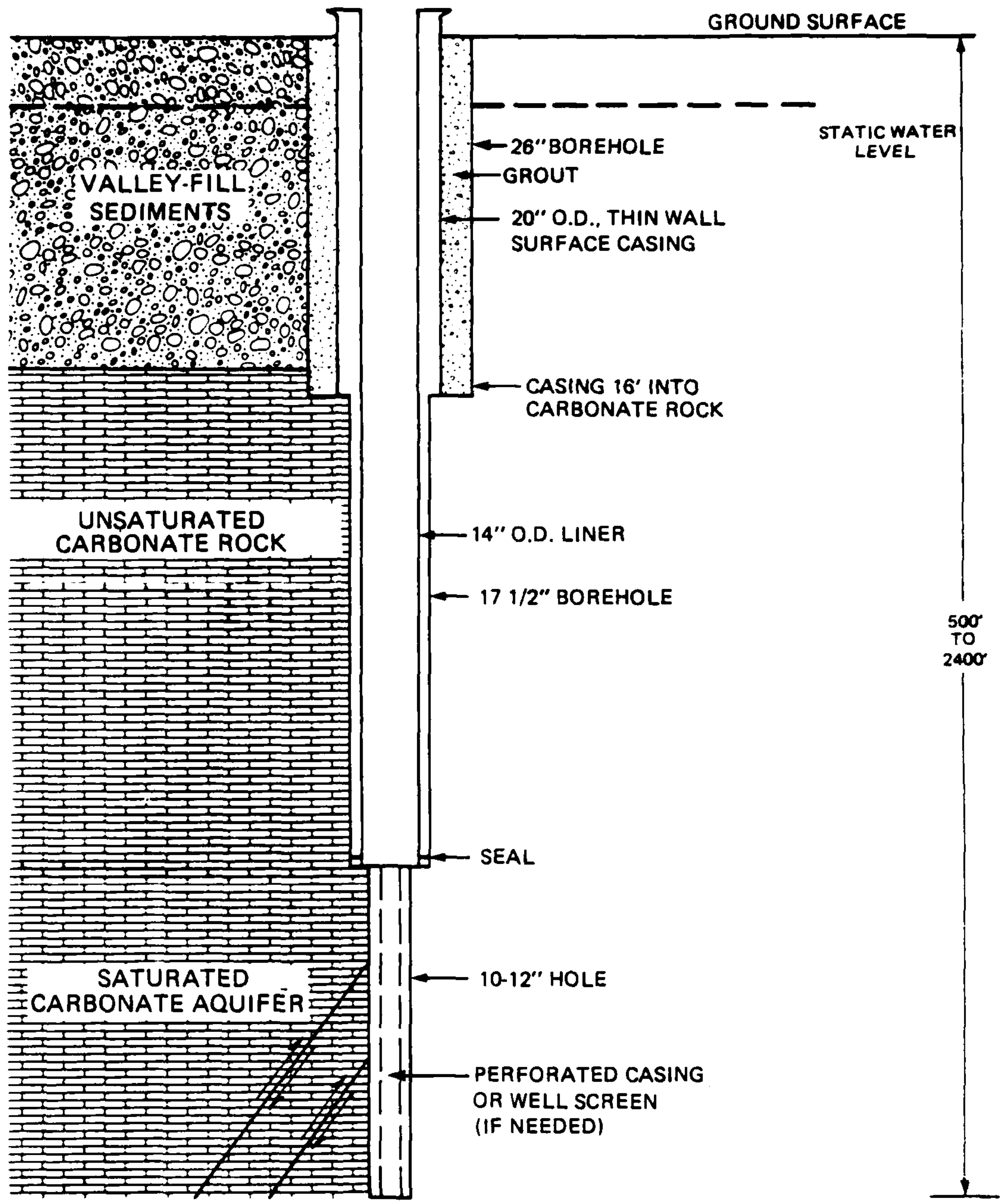
Water for domestic use should be stored in a closed tank so that the water quality does not deteriorate. Water stored in surface reservoirs should be used for construction purposes only. If water for domestic use is stored in a surface reservoir, increased costs will result because the water will require treatment prior to use.

3.3 REGIONAL AQUIFER DEVELOPMENT

3.3.1 Water-Supply Well Design and Construction

The depth and diameter of carbonate production wells will be dependent upon the depth and hydrologic characteristics of the hydrostratigraphic units present. In exploratory drilling and carbonate aquifer testing conducted by Ertec, drilling depths of up to 2395 feet (730 m) were required to penetrate suitable carbonate aquifers. The diameter of carbonate production wells should be at least 10 inches (25 cm) at the producing zone and thus may require diameters of up to 26 inches (66 cm) near the surface if telescoping wells are used (Figure 3-4).

The yield of carbonate wells can be expected to vary widely. Tests wells in carbonate aquifers in three deployment valleys and near the MOB had yields ranging from 95 to over 3400 gpm (6 to 215 l/s). In general, the location of carbonate wells in structurally deformed (faulted) areas of carbonate rock formations of Mississippian or Devonian age should have the highest yields.



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SCHEMATIC DESIGN OF MX CARBONATE AQUIFER WATER – SUPPLY WELL

28 SEPT 81

FIGURE 3-4

As with valley-fill wells, carbonate wells will impact water levels in the vicinity of the pumping well, although potentially to a much smaller degree in good producing zones. This is supported by the small drawdowns observed in the Coyote Spring Valley carbonate test wells, 5 to 12 feet (1.5 to 4 m) at pumping rates of 500 to 3400 gpm (32 to 215 l/s). The water distribution systems discussed in Section 3.2.2 are applicable to carbonate wells.

3.4 LEASE OR PURCHASE OF EXISTING WATER RIGHTS

Where there are insufficient unappropriated water supplies to meet MX demands, it may be possible to lease or purchase existing water rights. If a water right is so obtained, it may be desirable to transfer the point of diversion to a more suitable location. Such a relocation will require an application to be filed with the State Engineer stating the requested change. This application would be subject to the same publication, protest, and hearing process as an original application to appropriate water, although hearings for changes in points of diversion are manadatory only in Utah. A favorable ruling by the State Engineer approving the application is required before construction of a relocated well can begin.

It is advisable to consider leasing water rights rather than purchasing because leased water rights do not have to be disposed of following use, are less costly than purchased water rights, and would emphasize the temporary nature of the MX water requirement.

3.4.1 Impacts

Although the use of the lease/purchase alternative will eliminate many of the potential adverse impacts of MX water use upon existing water users and water levels, there will still be water-level declines around the pumping wells and setback distances from existing wells and environmentally sensitive areas will still have to be observed. If the existing point of diversion is used, the required water-distribution system would likely have some impacts.

If the lease or purchase of water supplies results in a decrease in the agricultural productivity of a valley, there may be indirect adverse impacts upon sectors of the agricultural economy. The Utah State Engineer has indicated that such impacts may be considered in evaluating proposed MX water development plans (personal communication, 1980).

3.5 INTERBASIN TRANSFER

In situations where water may not be obtained in a cost-effective manner by wells tapping either the valley-fill or carbonate aquifer or through the lease or purchase of existing water rights, it may be possible to import water supplies by pumping water from "water-rich" valleys via pipeline to water deficient areas. Water-rich valleys that have been identified are Railroad, Spring, and Snake valleys. These valleys have sufficiently large quantities of presently unappropriated perennial yield to supply the peak-water requirements of the other study valleys and very large estimates of ground-water in

storage within the upper 100 feet (30 m) of saturated valley-fill deposits. The general characteristics and the status of water rights in these valleys are described in Appendix A1.5. Although water importation would be costly, it could be a viable alternative where local water sources are not available.

If it becomes necessary to import water to a valley, pipelines, storage reservoirs, and lift pumps will be required. Pipelines would be constructed along roads to avoid additional environmental clearances and to increase maintenance efficiency. Storage reservoirs may be required to ensure that peak demands can be met.

The legality of interbasin transfers of water has not been well established. The Nevada State Engineer has indicated that it may be preferable to construct many small-yield wells in a water-deficient valley rather than import water from an adjacent valley. Until a policy has been issued, the legal feasibility of this alternative is in question.

3.5.1 Impacts

Although the importation of water will virtually eliminate any potential impacts of MX water development in the valley of use, it may compound potential impacts in the source valleys. The potential impacts discussed in Section 3.2.3 for valley-fill wells could occur but may be increased in magnitude if a higher pumping rate or longer pumping period is used to provide the exported water. Before this alternative could be implemented,

the source valley would have to be shown to have sufficient water supply and production capability such that no significant adverse impacts would result to existing users or the environment.

4.0 PRELIMINARY WATER MANAGEMENT PLANS

This section of the report discusses the general hydrology, water-supply source alternatives, suitable areas for water-supply well development, water-supply system alternatives, and additional investigations recommended for each of the 14 valleys studied.

A matrix evaluation was used to appraise the water-supply source alternatives for each valley and to identify the preferred source of water for MX construction. The criteria and approach used in this evaluation are discussed in Appendix A. The suitable primary and secondary areas and excluded areas for the construction of MX water-supply wells were delineated based on the criteria and methods described in Appendix B. Once the water-supply sources were ranked and the suitable areas for well development delineated, the viable water-supply system alternatives that would best meet MX water requirements were identified for each valley. These represent the practical application of the water-supply source and suitable water-supply well analyses toward supply water for MX.

A matrix evaluation was also used to aid in determining sites for additional drilling and investigation prior to operational development. The criteria and approach for selecting these sites are described in Appendix A. The purpose of the additional sites is to supply additional information, in advance of construction, beneficial to development of the ground-water

resources in each valley and to provide water-supply wells that meet the needs of the MX project. The criteria used to rank the sites take into account both of these purposes, though the criteria oriented toward information gathering (location of wells in areas of sparse data and in areas of moderate potential impact) are more heavily weighted than those oriented toward providing a water-supply well (well yield, proximity to construction camps, and clusters).

4.1 CAVE VALLEY

4.1.1 Hydrologic Summary

Cave Valley is a north-south trending, topographically closed basin in Lincoln and White Pine counties, Nevada. Of the 362 mi^2 (937 km^2) of valley area, 115 mi^2 (298 km^2) are suitable for MX deployment (Table 4-1). The ground-water resource of Cave Valley is sparsely developed. Certificated rights for ground-water use total 32 acre-ft/yr (0.04 hm^3/yr) (Woodburn and others, 1981) of the 2000 acre-ft/yr (2.47 hm^3/yr) perennial yield of the valley (State of Nevada, 1971). There is an estimated 1.0 million acre-feet (1233.0 hm^3) of water in storage in the upper 100 feet (30 m) of saturated valley-fill deposits. Presently there is no ground-water use in the valley (Woodburn and others, 1981), but there are approved ground-water rights at several locations. Withdrawal of the peak-year MX water requirement of 916 acre-ft/ yr (1.13 hm^3/yr) in 1984 can be met within the limits of the valley perennial yield.

Although there are no perennial streams in Cave Valley, Cave Valley Spring (9N-64E-16bdb), in the northern part of the

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg. Valley Width	Suitable Area	Avg. Valley Floor Elevation
362 sq mi	41 mi	9 mi	115 sq mi	6100 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	50-250 ft	5200-6600 ft	2400 sq ft/day	0.013

Perennial Yield	Ground-water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
2000	14,000	0	14,000	200	–

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds * Standards	Suitable for Construction	Exceeds ** Standards
11	4	7	11	0

WATER USE AND APPROPRIATIONS

Source	Current Use	Applications	Certificates, Proofs/Permits	Availability (1)
Ground Water	0	0	32	2000/1968
Surface water	1012	0	2643	–

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction Operation		137	711	259	358	207	0	0	0

(1) Perennial Yield − Current Use, Perennial Yield − Certificated Use
* State and Federal drinking water standards.
** Portland Cement Association recommendations (1968).

Note: All units are in acre feet per year unless otherwise noted.

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HYDROLOGIC SUMMARY
CAVE VALLEY, NEVADA

28 SEPT 81

TABLE 4-1

valley, discharges an estimated 400 to 1000 gpm (25 to 63 l/s). Water from Cave Valley Spring is fully appropriated, although not totally used.

The valley-fill aquifer of Cave Valley appears to be largely confined to semiconfined based on drillers' logs, although locally unconfined conditions may occur. An aquifer pump test of an Air Force test well (7N-63E-14ab) conducted by Ertec in Cave Valley indicates that the aquifer located there has a moderate transmissivity of about 2400 ft^2/day (288 m^2/day). The minimum storativity indicated by this seven-day test was 0.013. A minimum storativity of 0.02, the average minimum of longer pump tests conducted by Ertec in other deployment valleys, is believed to be more representative of the conditions expected throughout most of Cave Valley.

The regional carbonate aquifer underlies and is adjacent to the valley-fill aquifer in Cave Valley based on Air Force test well drilling logs and surface stratigraphy. The carbonate aquifer probably has a high potential for development because there are thick sequences of productive carbonate rocks of Devonian to middle Cambrian age present, and the valley is in a known regional flow regime. There are no aquitards, such as the Chainman Shale, expected to occur at common drilling depths. Also, there are only minor occurrences of volcanics.

Of the 11 samples of a ground water and surface water which were collected for chemical analyses, four of the samples met all state and federal drinking water standards and construction

water standards (Portland Cement Association, 1966). Six of the remaining seven samples exceeded state secondary standard for total dissolved solids, and one sample exceeded the state primary standard for total dissolved solids. All of the samples were suitable for construction purposes.

4.1.2 Water-Supply Sources

The acquisition of new permits and the construction of conventional water wells in the valley-fill aquifer is the preferred MX water-supply source in Cave Valley (Table 4-2). The close ranking of the alternatives of development of the carbonate aquifer and lease/purchase of surface-water rights suggests that some mixture of pumping from both the valley-fill and carbonate aquifers, as well as lease/purchase of rights to Cave Valley Spring (9N-64E-16bda), may be viable water-supply system alternatives for the valley.

The amount of ground water available for appropriation in Cave Valley is 1968 acre-ft/yr (2.43 hm^3/yr). This is sufficient to supply the peak-year MX water requirement of 916 acre-feet (1.13 hm^3) in 1984. Aquifer tests by Ertec in Cave Valley indicate that individual well yields on the order of 220 gpm (14 l/s) can be achieved. This is sufficiently high enough to supply the relatively small MX water requirements. The alternative of acquisition of new permits to withdraw water from the valley-fill aquifer is the least costly and can be developed in the least time of the four options.

Criteria	Weight	Valley-fill Aquifer		Carbonate Aquifer		Lease/ Purchase		Importation	
		Score	Wt. Score	Score	Wt. Score	Score	Wt. Score	Score	Wt. Score
Legal Water Availability	10	10	100	10	100	10	100	8	80
Impacts on Man or Environment	10	7	70	7	70	5	50	6	60
Development Potential (Physical Availability)	10	3	30	7	70	5	50	6	60
Cost	4	10	40	2	8	8	32	0	0
Timeliness	6	10	60	2	12	5	30	1	6
Water Quality	2	10	20	10	20	10	20	10	20
Final Weighted Score			320*		280+		282		266

* Recomended source of water supply

\+ First alternative source of water supply - shown as carbonate aquifer because of lower estimated impact potential to surface water users

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WATER-SUPPLY SOURCE MATRIX
CAVE VALLEY, NEVADA

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TABLE 4-2

Extraction of water from the carbonate aquifer is ranked lower than pumping from the valley-fill aquifer only because of the higher cost (about 5.5 times more expensive) and greater time (about four times as long) involved in drilling and developing a well in the carbonate rocks. It is considered as the first alternative, even though its score in Table 4-2 is essentially the same as lease/purchase because local water use is almost entirely from surface-water sources. The high development potential of the carbonate aquifer in Cave Valley suggests that the yield of a well drilled in the carbonate rocks could be greater than the yields in the valley-fill aquifer.

Approximately 1000 acre-ft/yr (1.23 hm^3/yr) of surface water is presently used, largely from Cave Valley Spring. It may be possible to lease or purchase a portion of this water to supplement water from the valley-fill aquifer, particularly during 1984, the year of peak MX water demand. However, lease or purchase of existing ground-water rights is not viable since there is presently only 32 acre-ft/yr (0.04 hm^3/yr) of certificated rights in the basin. In considering this option, one must include the need to temporarily abandon existing surface-water uses (farming, ranching) and, the cost of leasing or purchasing the water and of transporting the water from Cave Valley Spring to the use area.

Importation of water from another valley would not appear to be necessary because of the large amount of unused perennial yield in the valley. In addition, importation of water would be

costly (approximately 17 times more expensive than developing the valley-fill aquifer), would take more time than the other options (at least eight times the valley-fill time), and could possibly have negative impacts on Spring Valley which would be used as a source of water.

4.1.3 <u>Suitable Areas for Water-Supply Well Locations</u>

Drawing 4-1 shows the primary and secondary suitable areas for the construction of MX water-supply wells in the valley-fill aquifer in Cave Valley.

Due to the occurrence of lacustrine deposits throughout most of central and southern Cave Valley, only two small areas in the northern and central part of the valley are classified as primary areas for water-supply well development. One area contains less than 5 mi^2 (13 km^2) and occurs in Township 11N which is located a considerable distance from MX construction activities. The other contains about 4 mi^2 (10 km^2) in Township 8N and is nearer MX construction activities. Because the total area classified as primary is less than 10 mi^2 (26 km^2), there are no Air Force water-appropriation application points of diversion in a primary area.

An area in the south and central portions of Cave Valley, extending from Township 6N to Township 8N, has been classified as a secondary area for construction of valley-fill water-supply wells due to the presence of thick accumulations of lacustrine deposits. Here, the aquifer materials probably have lower

permeability than those in the primary area and the water may be of poorer quality. Only one of the six Air Force water-appropriation application points of diversion lie within suitable area for water-supply well development. This is located at 7N-63E-33db (number 41696).

A 15 mi^2 (39 km^2) area of shallow bedrock located in Township 9N and 10N has been excluded. In this area, a number of fee-land and water appropriation exclusions are also found. South of this area, six other ground-water appropriation exclusion areas (a 1-mile [1.6-km] radius from the point of diversion) have been identified. Five of the six Air Force water-appropriation application points of diversion lie within excluded areas for water-supply well development. Four are within shallow rock exclusion areas, and one, site of the Air Force test well at 7N-63E-14ba (number 41701), is about 0.8 mile (1 km) from a possible well for which an existing water right has not yet been verified. If a well is present and a water right exists, it could affect the viability of using the Air Force test well for water supply.

There are no regional springs in Cave Valley, however, there are several small springs in Townships 9N and 10N near the rock valley-fill contact along the eastern mountain front that are probably derived from meteoric sources (rainwater and snowmelt). The largest spring in the valley, Cave Valley Spring, is located at 9N-64E-16bda in the northern part of the basin and would not be a significant exclusion site if MX water-well development occurs in the south.

4.1.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses, there are three viable MX water-supply system alternatives for Cave Valley. The three alternatives are described below and are listed in order of priority.

4.1.4.1 Alternative I

This alternative consists of the construction of one MX water-supply well in the valley-fill aquifer in the primary water-supply well development area in the north-central part of the valley and the use of the existing Air Force test well at 7N-63E-14ab (number 41701).

The principal advantage of this alternative is that it would require only one additional valley-fill aquifer well to be constructed. The principal disadvantage is that one of the pending Air Force points of diversion would have to be amended.

There is no LSC proposed for Cave Valley. The MX water demand for the construction of DTN and clusters ranges from 183 to 916 acre-ft/yr (0.23 to 1.13 hm^3/yr). The existing Air Force test well located at 7N-63E-14ab (number 41701) is capable of supplying the annual demand for all but the peak year. An additional well, preferably located in the primary water-supply well area at 8N-64E-22cd, should be capable of supplying the additional water needed. After 1984, it would be possible to either reduce the pumping rates of both wells or use only one well to fulfill the MX water requirement.

4.1.4.2 Alternative II

The second alternative MX water-supply system in Cave Valley consists of the deepening of the existing Air Force test well at 7N-63E-14ab (number 41701) to increase the yield of the well to meet the peak-year MX demand. The well is probably tapping water from both the valley-fill and carbonate aquifers, and deepening the well may penetrate a greater saturated thickness of the carbonate aquifer.

The existing test well is constructed with an 18-inch (46-cm) borehole and 10-inch (25-cm) ID casing to a total depth of 463 feet (141 m) below land surface. During drilling, limestone bedrock was penetrated at a depth of 363 feet (111 m). Well screens were emplaced at 210 to 250 (64 to 76 m) and 375 to 435 feet (114 to 133 m) below land surface, and a constant well discharge rate of 223 gpm (14 l/s) was obtained from the well with a maximum drawdown of 115 feet (38 m) below land surface during testing. If an additional 345 gpm (22 l/s) can be obtained by deepening the well, then no additional MX water-supply wells will be required in Cave Valley.

The primary advantage of this approach is the elimination of the need for an additional water-supply well to meet MX demands. The major disadvantage is that 568 gpm (36 l/s) exceeds the 1.0 cfs (449 gpm [28 l/s]) rate of withdrawal requested in the appropriation application for this site. Amending the application to exceed this rate could cause delays in this site being available for additional development pending the Nevada State

Engineer's review. Also, there is a risk that additional yield will not be developed.

4.1.4.3 Alternative III

The third alternative MX water-supply system in Cave Valley consists of the use of the existing Air Force test well as in Alternative I and the lease of water to augment the existing well only during the peak-demand year of 1984.

Water appropriation and use data for Cave Valley indicate that, at present, there are 1013 acre-ft/yr (1.25 hm^3/yr) of surface water use primarily for agricultural purposes. It may be possible for the Air Force to lease 557 acre-feet (0.69 hm^3) of surface water during 1984. In 1983 and after 1984, all MX water requirements can be met with the existing test well.

The principal advantage of this water-supply alternative is that only about 359 acre-feet (0.44 hm^3) of ground water would be withdrawn which would reduce the potential for impacts. The principal disadvantage is that a water-distribution system (including pipelines) would have to be developed to convey water from the surface-water sources in the northern portion of the valley, and there may be some impacts from construction of such a system. Also, the agriculture industry in the valley would be temporarily impacted.

4.1.4.4 General Well Characteristics

Based upon the results of aquifer tests of an Air Force well conducted by Ertec, well yields of at least 223 gpm (14 l/s) can

be obtained in Cave Valley. The test well was constructed with an 18-inch (46-cm) borehole and a 10-inch (25-cm) ID casing. If an additional well is constructed in the valley, and it is found that the aquifer is more productive, it is recommended that a well with a 20-inch (51-cm) borehole and 12-inch (31-cm) casing be constructed.

4.1.5 Additional Investigations

An additional well site for test drilling and investigation prior to operational development of the water-supply system is identified in Drawing 4-1.

A site for additional drilling has been selected in the primary water-supply well area at 8N-64E-22cd in the northern part of the valley about 6.5 miles (10.5 km) northeast of the Air Force test well. This is an area where the projected saturated thickness of the valley-fill aquifer combined with the absence of lacustrine deposits suggest a higher well yield potential than that developed from the Air Force test well. However, this location is not an existing point of diversion for an Air Force water-appropriation application.

As indicated in Drawing 4-1, the Air Force water-appropriation points of diversion numbers 41697, 41698, 41699, and 41700 located at 6N-64E-8bc, 6N-63E-21cc, 8N-64E-9ba, and 7N-64E-3bc, respectively, lie within areas excluded for valley-fill water-supply well development. The only point of diversion remaining, other than at the Air Force test well located at 7N-63E-14ab

(number 41701), is located at 7N-63E-33db (number 41696) at the margin of a secondary drilling area. This location is only about 4 miles (6 km) southwest of the Air Force test well and is nearer the mountain front. For these reasons, additional drilling and investigation at this location in advance of operational development would probably not be beneficial.

4.2 COAL VALLEY

4.2.1 Hydrologic Summary

Coal Valley is topographically partially open to Garden Valley along its western margin. The basin trends north-south and is located in Lincoln and Nye counties, Nevada. Of the 460 mi^2 (1191 km^2) of valley area, 240 mi^2 (621 km^2) are suitable for MX deployment (Table 4-3). The ground water in Coal Valley is presently undeveloped, although there are 6515 acre-ft/yr (8.03 hm^3/yr) of pending applications for ground-water withdrawals in the valley. The perennial yield of the valley is estimated at 6000 acre-ft/yr (7.40 hm^3/yr) (State of Nevada, 1971). Water in storage within the upper 100 feet (30 m) of saturated sediment is estimated at 1.5 million acre-feet (1849.50 hm^3) (State of Nevada, 1971). Withdrawal of the peak-year MX water requirement of 2245 acre-ft/yr (2.77 hm^3/yr) in 1984 is well below the unappropriated perennial yield available unless a significant proportion of the 6515 acre-ft/yr (8.03 hm^3/yr) of pending appropriations is approved and withdrawal starts prior to 1988, the last year of scheduled MX construction activity in the valley.

The valley-fill aquifer of Coal Valley appears to be largely unconfined, although lacustrine clays may produce locally confined or semiconfined conditions. An aquifer pumping test of an Air Force test well (1S-59E-34cb) conducted by Ertec at a sustained rate of 450 gpm (29 l/s) for 10 days indicates a moderately productive transmissivity of the valley-fill aquifer of

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg Valley Width	Suitable Area	Avg Valley Floor Elevation
460 sq mi	36 mi	[illegible] mi	240 sq mi	5000 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	850 ft	4000-4800 ft	2500 sq ft/day	0.01
Carbonate	900 ft		400 sq ft/day	–

Perennial Yield	Ground-Water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
6000	2000	8000	10 000	0	400

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds * Standards	Suitable for Construction	Exceeds ** Standards
3	3	0	3	0

WATER USE AND APPROPRIATIONS

Source	Current Use	Applications	Certificates, Proofs/Permits	Availability (1)
Ground Water	0	[illegible]	1	[illegible]
Surface Water	17	5	184	–

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction Operation	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0

(1) Perennial Yield – Current Use / Perennial Yield – Certificated Use
* State and Federal drinking water standards
** Portland Cement Association recommendations (19[illegible])

Note: All units are in acre-feet per year unless otherwise noted

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HYDROLOGIC SUMMARY
COAL VALLEY, NEVADA

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TABLE 4-3

about 2800 ft^2/day (260 m^2/day) at that location. The minimum storativity indicated by this test is 0.01.

Based on Ertec studies, the regional carbonate aquifer, underlying and adjacent to the valley-fill aquifer, is considered to have a high potential for development because of the presence of appropriate carbonate units at drillable depths, the absence of aquitards, the presence of areas of extensive faulting, and the existence of a regional flow system underlying Coal Valley. Development of individual wells with good production potential in the carbonate aquifer is, however, not guaranteed. Aquifer tests conducted by Ertec in a carbonate test well near the Coal-Garden Valley boundary (3N-59E-10bd) showed an estimated transmissivity of only 400 ft^2/day (38 m^2/day), which is significantly less than that of the valley-fill aquifer. This well was not situated, however, in an area of extensive fracturing which has been demonstrated by subsequent Air Force carbonate aquifer test wells in other valleys to be an important factor in well productivity. These results underscore the higher risk involved in attempting to develop the regional carbonate aquifer.

Development of ground water from either the valley-fill or regional carbonate aquifer is considered feasible from a water-quality standpoint. All water samples collected by Ertec were found to meet both state and federal drinking water standards for all constituents tested.

4.2.2 Water-Supply Sources

The acquisition of new permits and the construction of water wells in the valley-fill aquifer is presently the preferred MX water-supply source in Coal Valley (Table 4-4). The ranking of this water-supply option could change if the pending applications for ground-water rights are granted prior to those of the Air Force. However, the State Engineer could still grant the Air Force additional ground-water rights regardless of the ruling on the prior applications. The relatively close ranking of ground-water development of the valley-fill aquifer and the carbonate aquifer suggests that some combination of the two may also be a reasonable option.

The available perennial yield from the valley-fill aquifer is about 6000 acre-ft/yr (7.40 hm^3/yr). The Air Force test well located in the valley-fill aquifer (1S-59E-34cb) has been shown to be capable of supplying 450 gpm (29 l/s) or 725 acre-ft/yr (0.89 hm^3/yr) if pumped continuously. However, this test location is not an appropriation point of diversion and will require a change in the point of diversion of one of the existing applications to this point. Development of the valley-fill aquifer is estimated to be the least costly and most timely to develop of the four water-supply options.

Development of the carbonate aquifer through the acquistion of new permits is considered second to developing the valley-fill aquifer as a source of water supply in Coal Valley. The carbonate aquifer has a high development potential, as discussed in

		Valley-fill Aquifer		Carbonate Aquifer		Lease/ Purchase		Importation	
Criteria	Weight	Score	Wt. Score	Score	Wt. Score	Score	Wt. Score	Score	Wt. Score
Legal Water Availability	10	10	100	10	100	1	10	8	80
Impacts on Man or Environment	10	9	90	9	90	5	50	4	40
Development Potential (Physical Availability)	10	5	50	9	90	5	50	10	100
Cost	4	10	40	5	20	9	36	2	8
Timeliness	6	10	60	2	12	5	30	1	60
Water Quality	2	10	20	10	20	10	20	10	20
Final Weighted Score			360*		332+		196		308

* Recommended source of water supply
\+ First alternative source of water supply

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WATER-SUPPLY SOURCE MATRIX
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TABLE 4-4

Section 4.2.1, although wells should be constructed in highly fractured areas for best yields. Carbonate aquifer development is also considered to have a low impact potential because of the lack of ground-water use and regional springs in the area. This source of water supply is two times more costly and will take four times longer to develop than valley-fill aquifer development.

Importation of water from Railroad Valley, the water-supply source valley, to Coal Valley ranked third among the four water-supply options because of the potential impact of additional withdrawals in Railroad Valley, the high cost (approximately 15 times as expensive as the valley-fill alternative), and the long time (16 times as long as the valley-fill alternative) to construct the necessary pipeline and pumping facilities. However, well yields are potentially higher and pumping costs would be lower in Railroad Valley because of shallower depths to water.

The lease/purchase option is ranked low because there are no existing permits for ground-water use in Coal Valley. If a significant proportion of the 6515 acre-ft/yr (8.03 hm^3/yr) of pending applications are approved, it would be feasible to obtain water by lease or purchase.

4.2.3 Suitable Areas For Water-Supply Well Locations

The primary and secondary areas for the construction of MX water-supply wells in Coal Valley, Nevada, are shown in Drawing 4-2.

Two primary areas have been delineated in Coal Valley on the basis of the selection criteria. In the eastern part of the valley, a 0.5- to 2-mile (0.8- to 3-km) wide primary area occurs along the alluvial fan slope extending for about 14 miles (23 km) from Township 1S to Township 3N. In the southern part of the valley, a primary area of about 16 mi^2 (41 km^2) also occurs along the alluvial fan slope in Townships 1S and 2S. Four of the nine Air Force applications for ground-water rights lie within primary areas for water-supply well development. These are application numbers 41709, 41708, 41706, and 41702 at 1N-60E-33cd, 1N-60E-16db, 2N-60E-27db, and 1S-59E-34aa, respectively.

These primary areas are expected to be capable of providing an adequate ground-water supply for the construction and operation of the MX missile system.

Due to lacustrine and playa sedimentation in Coal Valley, an extensive area is classified as secondary. This area, located in the central portion of the valley, consists of sediments that have low permeability, and ground water within these deposits may be of poor quality. Two additional secondary areas are delineated; one at the extreme northern end of the valley in Townships 3N and 4N and the other at the southern end of the valley in Townships 1S and 2S. Data indicate that these are areas where saturated thickness may be less than 200 feet (61 m) and well yields are likely to be small. There are four Air Force applications for ground-water rights located in secondary

areas for water-supply well development. These are application numbers 41710 (3N-59E-1dd), 41705 (2N-60E-9dd), 41707 (2N-60E-6cc), and 41703 (1S-59E-16ad).

There are two 1 mi^2 (2.6 km^2) fee-land exclusions located in the northern part of the valley. There is one possible existing well or ground-water appropriation exclusion area (a 1-mile [1.6 km] radius from the point of diversion) in the western portion of the valley. This location has not been verified as an approved ground-water appropriation diversion point, but it is presently assumed, for conservatism, that a water right exists. There are two existing surface water appropriation exclusion areas (a 1-mile [1.6-km] radius from the point of diversion or spring location) that affect the suitable drilling areas, one in the central portion of the valley and the other in the northern extremity of the valley. The former point is a proof for an undetermined source, presumably surface water, and the latter point is a certificated water right for a spring discharge. Only one Air Force appropriation application point of diversion is located in an excluded area (number 41704 at 3N-60E-21bb).

There are no known regional or possible regional springs in Coal Valley.

4.2.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of the investigation, there are two viable MX water-supply alternatives for Coal Valley. These alternatives are discussed below in order of their priority.

4.2.4.1 Alternative I

This alternative involves the use of the existing Air Force valley-fill test well at 1S-59E-34cb and the construction of three additional MX water-supply wells at three of the remaining eight pending appropriation application points of diversion filed by the Air Force. The Air Force test well is not presently a point of diversion, and the point of diversion for application number 41702 at 1S-59E-34aa should be changed to the test well site.

The proposed LSC, presumed to be located at 2N-59E, will require from 239 to 1067 acre-ft/yr (0.29 to 1.32 hm^3/yr) during the peak-year requirement in 1986. Two water-supply wells will be required to provide the water needed for use at the LSC. Assuming a well yield of 450 gpm (28 l/s) or 725 acre-ft/yr (0.89 hm^3/yr) if pumped continuously, a well constructed at the pending point of diversion located at 2N-60E-6dd (number 41707) can be used to supply the entire LSC water requirement in 1983 and 1984 and all but 46 acre-feet (0.06 hm^3) of the LSC water demand in 1985. An additional well, preferably located at the pending point of diversion at 1N-60E-16db (number 41708), will be required to supply the remainder of the LSC water requirement in 1985, 1986, and 1987. Surplus pumpage from these wells can be used for DTN and cluster construction in the northern and west-central part of the valley.

The proposed additional MX water-supply well at 3N-59E-1dd (number 41710) and the existing Air Force valley-fill test well

at 15N-59E-34cb will be capable of supplying the entire MX water demand for DTN and cluster construction. The proposed LSC water-supply well at 2N-60E-6dd (number 41707) can be used to supply the water requirement for DTN construction in 1983, but all four wells will be required in 1984 to meet the peak-year MX water demand. Following this peak year, the pumpage rates can be adjusted to the required water demand. For example, in 1987, 820 acre-feet (1.01 hm^3) are required for LSC use and 529 acre-feet (0.65 hm^3) for construction purposes. This is equivalent to a pumpage rate of 836 gpm (54 l/s); the pumpage rates of the existing Air Force test well and the three proposed wells could be reduced to an average of only 209 gpm (14 l/s) to meet this requirement.

The principal advantage of this water-supply system alternative is that it could be constructed in a very cost-effective manner in a minimum amount of time. The principal disadvantage is that the existing Air Force test well is presently not a point of diversion and a change in one of the Air Force applications would be necessary. If this change is made subsequent to the approval of Air Force water appropriation applications by the State Engineer, then there would be a delay for only the point of diversion to be changed and no delays in the development of the others would occur.

4.2.4.2 <u>Alternative II</u>

The second alternative MX water-supply system in Coal Valley is the use of the existing Air Force test well at 1S-59E-34cb and

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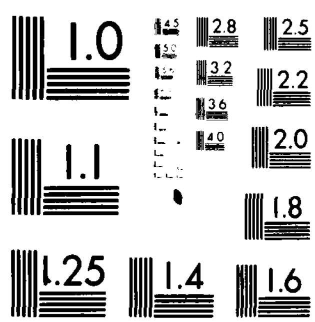

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

the construction of one regional carbonate aquifer water-supply well. The carbonate aquifer is ranked high in development potential in Section 4.2.2 based on the presence of thick favorable hydrostratigraphic carbonate units, the lack of thick aquitards, the presence of high density faulting, minimal land-use restrictions on favorable drilling areas, and other considerations. It is estimated that a well tapping the regional carbonate aquifer in Coal Valley could possibly yield about 900 gpm (56 l/s) if drilled in a favorable area. This is equivalent to 1449 acre-ft/yr (1.79 hm^3/yr) if pumped continuously and would supply nearly 65 percent of the MX peak-year water requirement of 2245 acre-ft/yr (2.77 hm^3/yr). This would also satisfy 100 percent of the peak-year (1987) water requirement for the LSC.

The use of a carbonate aquifer well would require pipelines to convey the water to more strategic locations for construction and domestic use in the valley. Also, depending on the final location of the LSC, water may have to be conveyed by pipeline to the LSC because favorable drilling areas lie to the north.

The principal advantage of this alternative is that only one additional well would be required to meet the MX water requirements in Coal Valley. The principal disadvantage is that neither the Air Force test well at 1S-59E-34cb nor the proposed carbonate well would be at an existing Air Force water-appropriation application point of diversion. This could delay the availability of water for Air Force use until the new points of diversion had been considered by the Nevada State Engineer.

4.2.4.3 General Well Characteristics

The Air Force test well constructed in the valley-fill aquifer was tested at a constant discharge rate of 450 gpm (28 l/s) with a maximum drawdown of 69 feet (21 m). This well was constructed with a 16-inch (41-cm) borehole and 10-inch (25-cm) ID casing to a total depth of 1315 feet (401 m). Although the depth to water is probably over 800 feet (244 m) in most of the valley, the depth to productive aquifers may be substantially greater. Therefore, it is recommended that MX water-supply wells be constructed to depths of at least 1300 feet (396 m).

The Air Force test well constructed in the regional carbonate aquifer was tested at a constant discharge rate of 95 gpm (6 l/s) with a maximum drawdown of 63 feet (19 m). The depth to the static water level was 803 feet (245 m) below ground surface, and the total depth of the well was 1835 feet (559 m) below ground surface. The low well yield and transmissivity of this well is believed attributable to the small diameter (7.9 inches [20 cm]) of the borehole and the correspondingly limited pump capacity. Also, this well was not in a highly fractured area. It is recommended that wells tapping the regional carbonate aquifer be drilled to at least 1835 feet (559 m) below ground surface in this area, have well diameters of at least 10 to 12 inches (25 to 30 cm) at pumping levels, and be constructed in highly fractured areas.

4.2.5 Additional Investigations

Suggested sites for additional drilling and testing prior to operational development of the water-supply system are identified in Drawing 4-2 and are ranked in Table 4-5.

A pending Air Force point of diversion, number 41707 has been identified as the first priority for additional drilling and testing in Coal Valley. This site is located in the north-central part of the valley at 2N-60E-6cc in the secondary water-supply area delineated in Drawing 4-2. Water quantity and water-chemistry data obtained from a well located at the site could be used for planning domestic water supply of the proposed construction camp located in 2N-59E. The proposed site is also well positioned with respect to the clusters and is located along the DTN route.

The second priority site, proposed Air Force point of diversion number 41708 (1N-60E-16db), is located in east-central Coal Valley in a primary water-supply area. A well at this location could provide the aquifer data necessary to evaluate the potential of the alluvial fans along the eastern side of the valley as a water-supply source. This site is located farther from the construction camp and DTN than appropriation numbers 41705 and 41706, and, therefore, has a lower final score. However, a well at this location would provide the best data concerning the valley-wide characteristics of the aquifer while maintaining a high potential as an MX water-supply well.

CRITERIA	POINTS OF DIVERSION						
		41702 + 1S-59E-34aa		41703 1S-59E-16ad		41709 1N-60E-33cd	
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	4	20	2	10	1	5
Proximity to Const. Camp or Plant	6	0	0	0	0	1	6
Proximity to DTN or cluster	4	6	24	5	20	4	16
Sparse Data Area	10	0	0	6	60	10	100
Final Weighted Score			44		90		127

* Recommended additional drilling site(s) at points of diversion
\+ Existing Air Force test and observation wells

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ADDITIONAL DRILLING/TESTING
SITE MATRIX
COAL VALLEY, NEVADA

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TABLE 4-6

CRITERIA		POINTS OF DIVERSION					
		41708 1N-60E-16db		41706 2N-60E-27db		41705 2N-60E-9dd	
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	2	10	2	10	2	10
Proximity to Const. Camp or Plant	6	2	12	5	30	5	30
Proximity to DTN or Cluster	4	6	24	6	24	7	28
Sparse Data Area	10	10	100	10	100	10	100
Final Weighted Score			146 *		164		168

* Recommended additional drilling site(s) at points of diversion

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ADDITIONAL DRILLING/TESTING
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CRITERIA	POINTS OF DIVERSION						
		41707 2N-60E-6cc		41704 3N-60E-21bb		41710 3N-59E-1dd	
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	2	10	2	10	2	10
Proximity to Const. Camp or Plant	6	10	60	3	18	3	18
Proximity to DTN or Cluster	4	6	24	5	20	3	12
Sparse Data Area	10	10	100	10	100	10	100
Final Weighted Score			194 *		148		140

* Recommended additional drilling site(s) at points of diversion

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ADDITIONAL DRILLING/TESTING
SITE MATRIX
COAL VALLEY, NEVADA

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TABLE 4-6

4.3 COYOTE SPRING VALLEY

4.3.1 Hydrologic Summary

Coyote Spring Valley is a north-south trending basin located in Clark and Lincoln counties, Nevada, and encompasses an area of 320 mi^2 (829 km^2). Coyote Spring Valley and adjoining Kane Springs Valley are considered a single hydrographic unit by the State of Nevada. This unit will be referred to as Coyote Spring Valley in this report.

The ground-water resources of Coyote Spring Valley are presently largely undeveloped (Table 4-6), however, there are some 18,859 acre-ft/yr (23.25 hm^3/yr) of pending applications and permits for ground-water withdrawal in the valley. According to the Nevada State Engineer's office (personal communication, 1981), these are comprised almost entirely of applications made under the Desert Land Entry Program (Carey Act). The perennial yield of the basin is estimated by the Nevada State Engineer's office (1971) to be about 18,000 acre-ft/yr (22.19 hm^3/yr). This value assumes yield from the regional carbonate aquifer. Eakin (1964) estimated the perennial yield at 2600 acre-ft/yr (3.21 hm^3/yr) based on local recharge. This latter figure is representative only of the valley-fill system and does not consider total water availability in the valley.

The valley-fill aquifer of Coyote Spring Valley is generally unconfined although there are several small areas where shallow perched ground-water systems occur. These perched ground-water systems are probably due to the presence of shallow, underlying, relatively impervious deposits in the valley fill. A slug

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg. Valley Width	Suitable Area	Avg. Valley Floor Elevation
320 sq mi	40 mi	8 mi	OB SITE	2000 - 2500 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	600 ft	1870 ft	-	-
Carbonate	350 ft	1810 ft	40,000 sq ft/day	-

Perennial Yield	Ground-Water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET	Surface (1) Discharge
18,000	2600	36,000	36,000	minor	-

WATER QUALITY

Total (4) Samples	Suitable for Consumption	Exceeds (1) Standards	Suitable for Construction	Exceeds * Standards
19	15	4	19	0

WATER USE AND APPROPRIATIONS

Source	Current Use	Applications/ Permits (3)	Certificates/ Proofs	Availability (2)
Ground Water	< 100	18,259	-	17,900/18,000
Surface Water	-	6	32	-

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction Operation	366	2343	2010	7322	9685	6750	4685	4635	965

(1) TDS concentrations exceed Nevada secondary limit and fluoride concentration in one sample exceed Nevada primary limit
(2) Perennial Yield - Current Use / Perennial Yield - Certificated Use
(3) Mostly applications under Desert Land Entry program, few permits
(4) Includes Muddy River Springs area
(*) Portland Cement Association recommendations (1966)

Note: All units are in acre-feet per year unless otherwise noted.

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HYDROLOGIC SUMMARY
COYOTE SPRING VALLEY, NEVADA

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TABLE 4-6

permeability test conducted by Ertec on an Air Force test well (12S-63E-29da) (December 1980) indicates low transmissivity (120 ft^2/day [11.1 m^2/day]) in the central portion of the valley.

A test well was installed by Ertec in the southern portion of Coyote Spring Valley (13S-63E-23dd) to evaluate the water-bearing and well-yield capabilities of the carbonate rock units. A short-term constant discharge test provided an estimated transmissivity value of 40,000 ft^2/day (3717 m^2/day) for the carbonate aquifer. Ongoing testing at a 628-foot (191-m) deep, large diameter (17.5 inches [44 cm]) carbonate well recently installed at the same location indicates a sustained production capacity of at least 3400 gpm (215 l/s) with only about 11 to 12 feet (3 to 4 m) of drawdown. This aquifer is part of the White River regional ground-water flow system that underlies a significant area in southeastern Nevada and is considered to have a high potential for development as a water-supply source. Static water level in southern Coyote Spring Valley is about 350 feet (107 m) below land surface. Evidence is not conclusive as to the degree of confinement of the system. Movement of ground water in the system is probably concentrated in highly fractured zones related to faulting. Test results suggest potential yields of water from the carbonate aquifer more than adequate to meet OB water-supply requirements for construction and operational use.

Development of ground water in Coyote Spring Valley is considered feasible from a water-quality standpoint. With the exception of the carbonate aquifer test well, all water samples

collected by Ertec were found to meet both federal and state drinking water standards for all constituents tested. Based only on one analysis, water from the initial carbonate aquifer test well exceeded the federal and state standards for fluoride.

4.3.2 Water-Supply Sources

The acquisition of a water right and the construction of water wells in the carbonate aquifer is the preferred water-supply source for the OB in Coyote Spring Valley (Table 4-7). An Air Force test well tapping the regional carbonate aquifer in this valley yielded 3400 gpm (215 l/s) of ground water during testing. This rate of discharge can supply nearly 60 percent of the peak construction water requirement and 100 percent of the yearly operational requirement for the OB. Development of the carbonate aquifer is the least costly and most timely of the water-supply sources because two potential carbonate water-supply wells have already been constructed. The carbonate aquifer is considered to have a high legal availability because the perennial yield of the valley has been estimated by the Nevada State Engineer's office (1971) to be 18,000 acre-feet (22.19 hm^3), this value includes yield of the carbonate aquifer. The potential impacts of pumping ground water from the carbonate aquifer upgradient of the Muddy River Springs area have not been quantified. Testing is presently being conducted to evaluate these potential impacts. Muddy River Springs are the presumed terminal discharge of the White River regional flow system. The springs discharge about 36,000 acre-ft/yr (44.39 hm^3/yr) which is utilized for agricultural, domestic, and industrial purposes,

Criteria	Weight	Valley-fill Aquifer Score	Valley-fill Aquifer Wt Score	Carbonate Aquifer Score	Carbonate Aquifer Wt Score	Lease/ Purchase Score	Lease/ Purchase Wt. Score	Importation Score	Importation Wt. Score
Legal Water Availability	10	3	30	10	100	0	0	8	80
Impacts on Man or Environment	10	[illegible]	60	4	40	6	60	8	80
Development Potential (Physical Availability)	10	1	10	10	100	1	10	10	100
Cost	4	0	0	10	40	4	16	0	0
Timeliness	6	0	0	10	60	0	0	0	0
Water Quality	2	10	20	5	10	10	20	10	20
Final Weighted Score			120		350*		106		280+

* Recomended source of water supply
+ First alternative source of water supply

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WATER-SUPPLY SOURCE MATRIX
COYOTE SPRING VALLEY, NEVADA

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TABLE 4-7

for wildlife habitat, and for power plant cooling. Chemical analysis of water samples from the initial carbonate aquifer test well indicates a concentration of fluoride which exceeds state and federal primary drinking water standards. The water temperature is approximately 95° F (35° C). Consequently, the water may require treatment for domestic use.

The importation of water ranked second to carbonate aquifer development. The Colorado River is the only identified source of water for importation. The importation of Colorado River water would be feasible if Clark County, Nevada, allocates a portion of its unused Colorado River water allotment to the Air Force for long-term use at the Coyote Spring OB. Clark County does have a significant quantity (approximately 150,000 acre-ft/yr [184.95 hm^3/yr]) of presently unused Colorado River allotment, a portion of which may be available to the Air Force. The potential impacts of importation are relatively low; those that would occur would be associated with pipelines and pumping stations. Importation will have a high cost (approximately 46 times the cost of developing the carbonate alternate) and, according to a representative of the U.S. Bureau of Reclamation (1981), it may take up to four years to construct such a system.

The development of the valley-fill aquifer ranked third because the estimated yield of the valley-fill (2600 acre-ft/yr [3.21 hm^3/yr]) is low compared to the peak-year MX construction requirement of 9685 acre-feet (11.94 hm^3). Also, results of exploratory drilling in the valley-fill sediments by Ertec indicate that the valley-fill aquifer is probably incapable of

providing the well yields needed for OB construction. Many wells would have to be constructed to utilize this source, if it is viable at all. The costs and the time to develop this source would be significant.

The lease or purchase of existing water rights ranked last among the four options because there are at present insufficient permitted or certificated water rights in the valley.

4.3.3 Suitable Areas for Water-Supply Well Locations

Exploratory drilling and testing by Ertec indicate that insufficient quantities of water are available from the valley-fill aquifer in Coyote Spring Valley. To meet MX water requirements for the proposed MOB, the regional carbonate aquifer system is the most likely water-supply source. Selection criteria for suitable well locations have therefore been modified and are described in detail in Appendix B.

Two major areas of consideration for the selection of suitable well locations within the regional carbonate aquifer systems are stratigraphy and geologic structure. Regional studies of the carbonate aquifer systems conducted by Ertec have defined 11 major hydrostratigraphic units based mainly on their water-bearing characteristics. Movement of water through the regional carbonate aquifer systems appears to be controlled largely by normal faulting. Where aquifer units capable of transporting large quantities of water occur in areas of major faulting, they appear to provide optimum conditions for the location of the MX water-supply wells. The most suitable aquifer unit in Coyote

Spring Valley is composed mainly of carbonate rock formations of Devonian and Silurian age. Outcrops of this unit occur along the western mountain fronts of the Meadow Valley Range and the Delamar Mountains as shown in Drawing 4-3.

Major areas of faulting occur adjacent to this unit in Townships 12 and 13S along the R63-64E border in Coyote Spring Valley and in Township 10S in adjacent Kane Springs Valley.

Other suitable carbonate aquifer units capable of providing an adequate supply of water, but not as favorable as the Silurian and Devonian age units, occur within a BLM Wilderness Study Area and along the western front of the Meadow Valley Range.

Significant cultural exclusions occur within Coyote Spring Valley. Most lie within the boundaries of the Desert National Wildlife Range or six U.S. Bureau of Land Management (BLM) Wilderness Study Areas. There are only two known existing wells or ground-water appropriation exclusion areas (a 1-mile [1.6-km] radius from the point of diversion or well location) within Coyote Spring Valley. However, there are a number of ground-water appropriation applications which have been filed with the State Engineer's office but have not been granted permits.

In addition, there are also 17 surface-water appropriation exclusion areas (a 1-mile [1.6-km] radius from the point of diversion or spring location), most of which occur on the eastern side of the Delamar Mountains. All springs within the Muddy River Springs area are assumed to be regional springs and

are so identified by Ertec. Although this area is outside of Coyote Spring Valley, areas within 3 miles (4.8 km) of this concentration of springs have been excluded to emphasize their probable hydrologic connection with the regional carbonate aquifer system.

4.3.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are two viable MX water-supply alternatives for the proposed MOB in Coyote Spring Valley. Each alternative is discussed below in order of priority.

4.3.4.1 Alternative I

This ater-supply alternative consists of development of the regional carbonate aquifer through use of the existing Air Force carbonate test wells located at 13S-63E-23dd (number 44220) and the construction of one additional well, potentially in the vicinity of 11S-64E-6. It will also be necessary to amend the pending point of diversion from the nonproductive valley-fill test well at 12S-63E-29da (number 43804) to the proposed additional well.

Life Support Camp

The proposed LSC, presumed to be located in 13S-63E, will require from 113 to 4595 acre-ft/yr (0.14 to 5.67 hm^3/yr) of water. The carbonate test well at 13S-63E-23dd (number 44220) can be used to provide the entire LSC water requirement. In

addition, a water-distribution system, as discussed in Section 3.0, will be required.

Other MOB Facilities

Other MX water demands at the MOB in Coyote Spring Valley will include revegetation, road construction, dust control, and landscaping. The quantity of water required for nondomestic purposes at the MOB ranges from 132 to 5371 acre-ft/yr (0.16 to 6.62 hm^3/yr) with the peak-year demand in 1986. The existing test wells at 13S-63E-23dd are capable of supplying more than 100 percent of the peak-year, nondomestic water requirement. However, when domestic water requirements are included, the additional carbonate aquifer water-supply well in the vicinity of 11S-64E-6 would be needed to meet peak water demands. This potential well location is near the proposed Operational Base Test Site (OBTS).

4.3.4.2 Alternative II

This water-supply alternative consists of the importation of water via pipeline from Lake Mead on the Colorado River. The water could be obtained from Clark County, Nevada, which is the sole authorized user of the state's Colorado River allotment. The county is not projected to use the entire Nevada allotment of 300,000 acre-ft/yr (369.90 hm^3/yr) until the 1990 to 2000 time period. At present, approximately 150,000 acre-ft/yr (184.95 hm^3/yr) is unused. This amount will decrease as water use increases in Las Vegas but should remain in excess of MOB construction requirements in the 1982 to 1990 time period.

Operational water requirements at the MOB are projected beyond the year 2000. Use of Colorado River water for this purpose depends upon the length of the purchase period.

The purchase of Colorado River water would have to be negotiated by the Air Force with Clark County and the State of Nevada. Legislative action may be required to allow for use of Colorado River water outside of the authorized service area of the Las Vegas Valley Water District.

The construction of a pipeline from Lake Mead to Coyote Spring Valley will be expensive but is technically feasible. Operational energy costs will be significant because of the pumping lift. The in-valley water distribution system would be similar to that required for Alternative I.

4.3.4.3 General Well Characteristics

Test wells constructed by Ertec have penetrated water-bearing units in the carbonates which are capable of producing up to 3400 gpm (215 l/s). The maximum well yield is not known because the yields obtained were at the limit of capability of the pumps used for the test. It is likely that with larger pumps, the two existing carbonate wells would be capable of supplying the entire MOB water requirement. It is preferable, however, to construct an additional well rather than enlarge the existing wells due to location factors and the need for a back-up system in the event of mechanical failure of any of the wells.

The existing test wells are located about 13 miles (21 km) northwest of the Muddy River Springs area in Upper Moapa Valley.

The major springs in this area discharge ground water believed to be from the regional carbonate aquifer. To determine what impacts the proposed Air Force development of the carbonate aquifer in Coyote Spring Valley would have upon these springs, an extensive aquifer testing program is presently underway. The preliminary results of this program have indicated no effects upon the discharge rate of the springs. If long-term pumping of wells does cause a reduction in spring discharge, it will be necessary to reduce the pumpage at the existing wells and increase the pumpage at the proposed well in the northeastern part of the valley.

Based upon the results of the exploratory drilling previously conducted, it is recommended that any additional MX water-supply wells be constructed with telescoping casing design. This design would permit the installation of a liner in lost circulation zones above the potentiometric surface. Unlike other valleys within the MX deployment area, suitable wells tapping the regional carbonate aquifers in Coyote Spring Valley can be penetrated at relatively shallow depths. It is recommended that any additional MX water-supply wells tapping the regional carbonate aquifer be targeted to depths of less than 1000 feet (305 m).

4.3.5 Additional Investigations

Suggested possible sites for additional drilling and testing prior to operational development of the water-supply system are identified in Drawing 4-3. Data obtained from the Air Force test well located at 12S-63E-29da (number 43804) combined with

other hydrologic data have shown the valley-fill aquifer is not a viable MX water-supply source. Additional drilling and testing sites in the valley are limited to areas where there is a high potential for development of the carbonate aquifer.

In northern Coyote Spring Valley, an additional drilling and testing site has been identified at 11S-64E-6a. This site was selected based on the presence of suitable carbonate strata located at drillable depths (less than 1000 feet [305 m]) in an area of high density faulting. A well at this location could provide additional data concerning the performance of the aquifer and the regional flow regime within the carbonate rocks. It is also located in the vicinity of a proposed OBTS which increases its potential as an MX water supply.

4.4 DELAMAR VALLEY

4.4.1 Hydrologic Summary

Delamar Valley is a north-south trending basin in Lincoln County, Nevada, that is separated by low alluvial divides from Dry Lake Valley to the north and Pahranagat Valley to the southwest. It is a topographically closed basin with an area of about 383 mi^2 (992 km^2) of which 180 mi^2 (466 km^2) are suitable for MX deployment (Table 4-8). The ground water in Delamar Valley is largely undeveloped, with currently only 7 acre-feet (0.009 hm^3/yr) of ground-water diversions (DRI, 1980) and only 16 acre-ft/yr (0.02 hm^3/yr) in certificated water rights (Woodburn and others, 1981). There are no pending applications for ground-water withdrawal, hence a large portion of the estimated perennial yield of 3000 acre-ft/yr (3.70 hm^3/yr) (State of Nevada, 1971) is available for appropriation.

Ground-water in storage in the upper 100 feet (30 m) of saturated sediment is estimated at 1.2 million acre-feet (1479.6 hm^3) (State of Nevada, 1971). Withdrawal of the peak-year MX water requirement of 679 acre-feet (0.84 hm^3/yr) in 1984 is well below the unappropriated perennial yield.

The alluvial fill in Delamar Valley, based on drillers' logs, is composed of clay, silt, sand, and gravel in alternating layers of varying thickness. The aquifer system is generally unconfined, but locally confined or semiconfined conditions may exist because of layering of fine and coarse sediments. Data from an aquifer pumping test performed by Ertec in the central

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg Valley Width	Suitable Area	Avg Valley Floor Elevation
383 sq mi	31 mi	12 mi	180 sq mi	4600 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	800 ft	3600-4200 ft	1000 sq ft/day	–

Perennial Yield	Ground-Water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
3000	1200	5000	6000	minor	–

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds [illegible] Standards	Suitable for Construction	Exceeds [illegible] Standards
4	3	1	4	[illegible]

WATER USE AND APPROPRIATIONS

Source	Current Use	Applications	Certificated Proofs Permits	Availability[2]
Ground Water	7	0	[illegible]	[illegible]
Surface Water	37	0	[illegible]	–

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction	115	141	[illegible]	340	[illegible]	0	0	0	0
Operation									

[illegible] Air Force test well [illegible] exceeds recommended level but does not exceed maximum limit [illegible] state and federal drinking water standards

(2) Perennial Yield – Current Use [illegible] Perennial Yield – Certificated Use Portland Cement Association [illegible]

Note: All units are in acre-feet per year unless otherwise noted

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HYDROLOGIC SUMMARY
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part of the valley (6S-63E-12da) indicate that the transmissivity of the valley-fill aquifer is on the order of 1300 ft^2/day (111 m^2/day). Storativity was not computed because of inappropriate test conditions. A minimum storativity of 0.02 should be representative of conditions here since this is the average minimum storativity obtained from Ertec aquifer tests of 10 days or more in other MX valleys.

The combined discharge rate of four springs measured by Ertec in Delamar Valley in May 1980 total 53 acre-ft/yr (0.07 hm^3/yr). Present use is about 37 acre-ft/yr (0.05 hm^3/yr) (DRI, 1980). The springs are generally inaccessible because they are located in the mountains. The measured discharge of the springs is less than the total certificates, proofs, and permits for surface water in the valley.

Chemical analysis of water samples from three local springs and the Air Force test well indicate that all samples are within water-quality criteria established for construction (Appendix D) and all except water from the Air Force test well meet primary and secondary drinking water standards for the State of Nevada (Appendix D). Water from the Air Force test well (6S-63E-12da) has an iron concentration of 0.37 mg/l, which exceeds the recommended level of 0.30 mg/l for the State of Nevada but is still less than the maximum limit of 0.6 mg/l.

4.4.2 Water-Supply Sources

Valley-fill aquifer development through acquisition of new ground-water permits is the preferred water-supply source in

Delamar Valley (Table 4-9). The perennial yield of Delamar Valley is estimated by the Nevada State Engineer's office (1971) to be 3000 acre-ft/yr (3.70 hm^3/yr). After subtracting existing ground-water use, the quantity of ground water currently available for development is 2993 acre-ft/yr (3.69 hm^3/yr). After subtracting both existing permitted and certificated ground-water rights from perennial yield, the quantity of water available for development is 2984 acre-ft/yr (3.67 hm^3/yr).

The amount of water available for development is large compared to the estimated annual peak MX use of 679 acre-feet (0.84 hm^3) in 1984. Test drilling and an aquifer test conducted by Ertec indicate that ground water is deep and the sediments found in the valley-fill aquifer have a low yield potential, though it is adequate for MX needs. The test well produced 85 gpm (5 l/s) or, if pumped continuously, 137 acre-ft/yr (0.17 hm^3/yr). However, the MX water requirements are low in this valley making this a viable source of water supply. The valley-fill aquifer as a source of supply is the least costly and the most timely of the four options.

Development of the carbonate aquifer ranked second as a water-supply source on the basis of its estimated moderate potential for development, its legal availability, and the minimal impact its development would likely have on local water users and the environment. There are areas within the valley where high density faulting is present, which suggest potential sites for moderate yield wells.

Criteria	Weight	Valley-fill Aquifer Score	Valley-fill Aquifer Wt. Score	Carbonate Aquifer Score	Carbonate Aquifer Wt. Score	Lease/ Purchase Score	Lease/ Purchase Wt. Score	Importation Score	Importation Wt. Score
Legal Water Availability	10	10	100	10	100	1	10	8	80
Impacts on Man or Environment	10	9	90	9	90	6	60	6	60
Development Potential (Physical Availability)	10	2	20	4	40	4	40	10	100
Cost	4	10	40	5	20	8	32	0	0
Timeliness	6	10	60	2	12	7	42	1	6
Water Quality	2	10	20	10	20	10	20	10	20
Final Weighted Score			330*		282+		204		266

* Recommended source of water supply
\+ First alternative source of water supply

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WATER-SUPPLY SOURCE MATRIX
DELAMAR VALLEY, NEVADA

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The importation of water from Dry Lake Valley was ranked third as a source of water supply because it is the most costly (25 times the cost of developing the valley-fill alternative) and would take the longest time (at least 16 times as long as the valley-fill alternative) to develop of the four options considered. Importation of water was ranked ahead of the lease/purchase option, however, because of the relatively high physical availability and legal availability of ground water in the source valley, Spring Valley, compared to the physical and legal availability of water in Delamar Valley through the lease/purchase option.

The lease or purchase of existing water rights is not recommended as a source of water for MX in Delamar Valley because there are only 16 acre-ft/yr (0.20 hm^3/yr) of permitted and certificated ground-water rights. According to the Desert Research Institute (1980), approved surface water rights total 250 acre-ft/yr (0.31 hm^3/yr), but, as noted above, the four springs located in Delamar Valley and measured by Ertec in May 1980 have a combined discharge of only 53 acre-ft/yr (0.07 hm^3/yr). These springs are located in the mountains above the valley floor and are probably subject to seasonal fluctuations in discharge because of variable rainfall and snowmelt rates. There are no other known perennial sources of surface water in the valley, thus there is an insufficient quantity of water in Delamar Valley available for lease or purchase to meet peak-year demands.

4.4.3 Suitable Areas for Water-Supply Well Locations

Three primary water-supply well areas, separated by areas of shallow bedrock, have been identified (Drawing 4-4). Two of these areas are in the northern portion of the valley and have areas of less than 12 mi^2 (31 km^2) each. South of these is a larger primary area of approximately 50 mi^2 (129 km^2). Since MX construction activities will occur throughout the valley, the distribution of primary areas is suitable for the development of a ground-water supply. The only Air Force water-appropriation application point of diversion in the valley, located at 6S-63E-12da (number 40434, lies within a primary area for water-supply well development.

A 0.25- to 0.5-mile (0.4- to 0.8-km) wide secondary area has been delineated on the southwestern flank of the valley in Townships 6S and 7S. This area is classified as secondary on the basis of geophysical and water-level data which indicate that only thin saturated thicknesses of valley-fill sediments occur and small well yields are likely. Because of the adequacy of primary areas, it will not be necessary to use secondary areas for water-supply well locations.

There is one small cultural exclusion of about 0.25 mi^2 (0.65 km^2) located immediately outside the northern boundary. There are, however, nine water-appropriation exclusions. These exclusions include the area within a 1-mile (1.6-km) radius of existing ground-water or surface-water appropriations and all springs.

Extensive outcrops of bedrock occur in the northern part of the valley, and areas within 1 mile (1.6 km) from these outcrops are excluded.

There are no known regional springs in Delamar Valley.

4.4.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are two viable MX water-supply system alternatives for Delamar Valley. Each of the alternatives is discussed below in order of priority.

4.4.4.1 Alternative I

The first alternative MX water-supply system in Delamar Valley consists of the use of the existing Air Force test well at 6S-63E-12da (number 40434), if the pending application to appropriate water from this well is approved, amending the single point of diversion in the valley to multiple points of diversion, the construction of three additional MX water-supply wells in the valley-fill aquifer, and the storage of ground water in surface reservoirs prior to use.

The primary advantage of this alternative is that only three additional water-supply wells need be constructed. The main disadvantage of this plan is that, because of the expected low well yields in Delamar Valley, storage reservoirs may be required. There is no LSC scheduled for Delamar Valley.

For DTN and cluster construction, an estimated 116 acre-feet (0.14 hm^3) of water will be required in 1982. This amount can

be supplied from the existing Air Force test well located at 6S-63E-12da which has a sustained yield of 85 gpm (5.4 l/s) or 137 acre-ft/yr (0.17 hm^3/yr). During 1983, however, the MX water requirement will increase to 141 acre-feet (0.17 hm) and an additional well would be required. It may be possible, however, through the use of storage reservoirs, to reduce the number of wells required. It is recommended that, for Alternative I, MX water-supply wells and reservoirs be constructed and water stored prior to use for DTN and cluster construction.

In 1984, 679 acre-feet (0.84 hm^3) of water will be required in Delamar Valley. Of this amount, the existing Air Force test well is capable of supplying only 137 acre-feet (0.17 hm^3) leaving a deficit of 542 acre-feet (0.67 hm^3). Four additional wells of similar yield would be required to supply the deficit. By constructing storage reservoirs and wells at least one year prior to construction, the required number of additional wells could be reduced to three.

Assuming an infiltration rate of 30 inches (76 cm) per year, an evaporation rate of 50 inches (127 cm) per year (Eakin, 1963), a maximum water depth of 10 feet (9.3 m) in the storage reservoir, and a constant pumping rate of 85 gpm (5.4 l/s) per well, a storage reservoir of 8.2 acres (3.3 ha) would be required for each of the wells. The peak storage capacity of each reservoir would be 82 acre-feet (0.10 hm^3). If four wells are pumped for one year prior to actual use, it will be possible to store 328 acre-feet (0.40 hm^3) of water for use in 1984. The remaining

351 acre-feet (0.43 hm^3) required can be supplied from the pumpage of three wells during 1984.

In 1985, MX water requirements decline to only 340 acre-feet (0.42 hm^3) and this requirement can be met with pumpage from three wells. In 1985, it will be necessary to store additional water in the reservoirs to meet the requirement of 592 acre-feet (0.73 hm^3) in 1986, the final year of construction.

4.4.4.2 Alternative II

The second alternative MX water-supply system in Delamar Valley consists of the use of the existing Air Force test well at 6S-63E-12da (number 40434), if the pending application to appropriate water from this well is approved and the development of the carbonate aquifer for additional water supplies.

The development potential of the carbonate aquifer is considered to be moderate because of the presence of relatively high density faulting and the fact that Delamar Valley is part of a known regional flow system. The risk in attempting to develop a water-supply system in Delamar Valley is significant, however, since known carbonate aquifers are not exposed at the surface and aquitards are common in the stratigraphic section adacent to the valley.

4.4.4.3 General Well Characteristics

Due to limited ground-water development in Delamar Valley, there are few data concerning aquifer properties and well yields. The Air Force well is a 16-inch (41-cm) borehole and has a 10-inch

(25-cm) ID casing to a total depth of 1215 feet (370 m). Larger diameter wells may be capable of greater sustained yields, especially if a more permeable aquifer is penetrated. Although the depth to water is 800 feet (244 m) below land surface, the depth to productive aquifers may be substantially greater. Therefore, it is recommended that MX water-supply wells be constructed to depths of at least 1200 feet (366 m). Due to the lack of hydrologic data for aquifer characteristics and well yields for much of Delamar Valley, it is recommended that exploratory drilling be conducted to verify the proposed locations of any additional MX water-supply wells.

If development of the carbonate aquifer is pursued in Delamar Valley, wells up to 2000 feet (610 m) deep may be needed. Well characteristics could be similar to those described in Section 3.3.1.

4.4.5 Additional Investigations

Suggested possible sites for additional drilling and testing prior to operational development of the water-supply system are identified in Drawing 4-4.

Application number 40434 (6S-63E-12da) has been filed for a single point of diversion in central Delamar Valley and is at the Air Force test well site. The full quantity of water for peak MX construction in the valley was requsted for this single point of diversion due to time constraints in the appropriation-application process and to maintain the application priority

date. In southern and northwestern Delamar Valley, widely spaced stock wells provide insufficient data to evaluate the aquifer. Additional drilling and testing sites could provide the data necessary to more accurately evaluate yield potential of the aquifer as well as aid in selecting optimum locations for production wells.

Two drilling sites have been identified in addition to the pending point of diversion in Delamar Valley. These sites were selected along existing roads and in primary water-supply areas delineated in Drawing 4-4. These two sites will provide a better distribution of aquifer performance data across the valley. Based on the distribution of surficial geologic units, which are often indicative of varying aquifer conditions, the two proposed sites are considered adequate to characterize the general viability of aquifer characteristics within the valley.

The first site is located in the northwestern part of the valley at 4S-63E-20cd and is the first priortiy for additional drilling. No aquifer data are available within a 5-mile (8-km) radius of the site, which is west of the valley axis. A proposed construction camp in southern Dry Lake Valley is approximately 9 miles (14 km) to the northeast, and the DTN that runs between Pahroc and Dry Lake valleys is 2.5 miles (4 km) north of the site. These factors, as well as the site's good location among clusters, indicate the site could be utilized as a water supply should the aquifer testing indicate sufficient quantity and quality of water for MX use.

The second priority site (6S-64E-32ac) is located in southeast Delamar Valley approximately 4.5 miles (7 km) southeast of the existing Air Force test well and 4 miles (6 km) from a DTN. Existing data consist of two stock wells and the Air Force well, all located between 4 and 5 miles (6 and 8 km) from the site. Aquifer data collected at this site would better characterize aquifer conditions in the southern portion of the valley.

4.5 DRY LAKE VALLEY

4.5.1 Hydrologic Summary

Dry Lake Valley is a topographically open basin in Lincoln County, Nevada. Of the approximately 700 mi^2 (1813 km^2) of valley area, 310 mi^2 (802.9 km^2) are suitable for MX deployment (Table 4-10).

Dry Lake Valley is hydrologically connected with Muleshoe Valley, and the two valleys are considered as a single hydrographic unit by the Nevada State Engineer. Ground water in Dry Lake and Muleshoe valleys is essentially undeveloped, however, there are 20 acre-ft/yr (0.02 hm^3/yr) of pending applications and 19 acre-ft/yr (0.02 hm^3/yr) of certificated or permitted rights (Woodburn and others, 1981) for ground-water withdrawal. In addition, there is 21 acre-ft/yr (0.02 hm^3/yr) of surface water use (DRI, 1980) in the valley.

The perennial yield is estimated at 3000 acre-ft/yr (3.70 hm^3/yr) for the Dry Lake-Muleshoe basin (State of Nevada, 1971). The combined peak-year MX water requirements in the two valleys, 3373 acre-ft/yr (4.16 hm^3/yr) for Dry Lake and 968 acre-ft/yr (1.19 hm^3/yr) for Muleshoe, in 1984 would exceed the Dry Lake-Muleshoe basin perennial yield by 1341 acre-feet (1.65 hm^3). However, the combined total ground water in storage within the upper 100 feet (30 m) of saturated sediments in Dry Lake and Muleshoe valleys is estimated at 2.8 million acre-feet (3452.4 hm^3) (State of Nevada, 1971). This suggests that the ground-water basin could sustain the peak MX water demand if temporary overdraft is allowed by the Nevada State Engineer.

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg. Valley Width	Suitable Area	Avg. Valley Floor Elevation
700 sq mi	38 mi	18 mi	310 sq mi	4800 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	300-800 ft	4200-5000 ft	3300 sq ft/day	0.06
Carbonate	850 ft	_	13,000 sq ft/day	-

Perennial Yield	Ground-Water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
3000	2700	2100	5000	minor	-

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds (1) Standards	Suitable for Construction	Exceeds (4) Standards
[illegible]	5	1	[illegible]	0

WATER USE AND APPROPRIATIONS (2)

Source	Current Use	Applications	Certificates Proofs/Permits	Availability (3)
Ground Water	0	20	19	3000/2981
Surface Water	21	2596	-	-

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction Operation	196	414	3373	2458	2014	225	0	0	0

1. Well near Bristol Silver Mine - exceeds state primary standard for nitrate
2. Dry Lake and Muleshoe Valleys combined
3. Perennial Yield - Current Use
   Perennial Yield - Certificated Use
4. Portland Cement Association recommendations (1956)

Note: All units are in acre-feet per year unless otherwise noted.

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HYDROLOGIC SUMMARY
DRY LAKE VALLEY, NEVADA

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TABLE 4-10

Surface water supplies are limited to ephemeral streamflow and springs. The springs are located mostly in the mountains, are generally unaccessible, and have low discharge (less than 2 gpm [0.13 l/s]).

A 10-day aquifer pump test conducted by Ertec in the southern part of the valley (3S-64E-12ca) (number 40433) indicates a generally unconfined valley-fill aquifer having an average transmissivity of 3300 ft^2/day (306.6 m^2/day) and a storativity of 0.06. Confined or semiconfined conditions are, however, expected in other portions of the valley due to the complex nature of the valley fill which was found to be composed of variable thicknesses of clay, silt, sand, and gravel.

The regional carbonate aquifer underlying and adjacent to the valley fill is considered to have a high potential for development. Data from an aquifer test performed by Ertec in the northern part of the valley (3N-63E-27cc) indicate a transmissivity in the carbonate aquifer of 13,000 ft^2/day (1208 m^2/day). The test well was pumped at a sustained rate of 106 gpm (7 l/s) with a drawdown of only 2 feet (0.6 m). The hydrostratigraphic unit (Guilmette Formation and Simonson Dolomite) penetrated at the test site is considered to be a high-yield aquifer based on these investigations.

Water-chemistry tests on water samples collected by Ertec from both the valley-fill and carbonate aquifers show that all but one well, 3N-65E-21dba, meet primary and secondary drinking

water standards for the State of Nevada (Appendix D). This well, located in the northeastern part of Dry Lake Valley was found to have a nitrate concentration of 32 mg/l, which exceeds the 10 mg/l standard for nitrate. This well was, however, used for mining operations by the Bristol Silver Mine and is thought to be contaminated by mining-related activity.

4.5.2 Water-Supply Sources

Development of the valley-fill aquifer is the preferred source for the MX water supply in Dry Lake Valley (Table 4-11). Development of the valley-fill aquifer is projected to have the least potential impact on local water users and the environment, the highest physical development potential, and to be the least costly and the most timely to develop of the four water-supply options. The legal availability of ground water from the valley-fill aquifer was ranked second to importation because the estimated perennial yield of the hydrographic basin can supply only about 70 percent of the peak-year requirements. The quantity of ground water presently available for development, based on certificated and permitted water rights, is 2981 acre-ft/yr (3.68 hm^3/yr). The estimated combined peak-year water requirement for Dry Lake and Muleshoe valleys is 4341 acre-feet (5.35 hm^3) during 1984. However, there is essentially no ground-water use in Dry Lake Valley, and the State Engineer need not limit his decisions on the approval of ground-water applications to a comparison of approved water rights versus the perennial yield of the basin. Quantity, distribution, and type and length of

Criteria	Weight	Valley-fill Aquifer Score	Valley-fill Aquifer Wt. Score	Carbonate Aquifer Score	Carbonate Aquifer Wt. Score	Lease/Purchase Score	Lease/Purchase Wt. Score	Importation Score	Importation Wt. Score
Legal Water Availability	10	[illegible]	[illegible]	[illegible]	70	[illegible]	0	8	80
Impacts on Man or Environment	10	[illegible]	[illegible]	8	[illegible]	[illegible]	70	6	60
Development Potential (Physical Availability)	10	10	[illegible]	8	[illegible]	[illegible]	70	10	100
Cost	4	10	40	[illegible]	12	[illegible]	20	0	0
Timeliness	[illegible]	10	[illegible]	[illegible]	12	[illegible]	42	1	6
Water Quality	2	[illegible]	[illegible]	10	[illegible]	[illegible]	20	10	20
Total Weighted Score			[illegible]		[illegible]		222		266

* Recommended source of water supply

[illegible]

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WATER-SUPPLY SOURCE MATRIX
DRY LAKE VALLEY, NEVADA

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TABLE 4-11

current and proposed ground-water use is considered as well as the quantity of water in storage in the aquifer.

The development of the carbonate aquifer in Dry Lake Valley is considered a much more feasible alternative source of water supply than importation of water, even though it ranked only slightly higher than importation in the matrix evaluation. The results of a carbonate aquifer test conducted by Ertec near the northwest margin of the valley indicate that the carbonate aquifer has a high potential for development; however, development of the carbonate aquifer would be about three times more costly than the valley-fill aquifer and would require four times more time to construct the supply wells. The relatively high yield potential indicated by the existing carbonate test well suggests that some combination of pumping from the valley-fill and the carbonate aquifers may be viable.

Importation of water is ranked third among the four options, although it compares favorably with development of the carbonate aquifer. Importation ranked high because of the legal and physical water availability in the source valley, which would be Spring Valley. The matrix evaluation is weighted more toward legal and environmental considerations of water use and less toward MX water-supply system construction. However, importation of water from the nearest valley where it is plentiful is estimated to cost as much as 40 times development of the valley-fill aquifer and 14 times development of the carbonate aquifer.

Lease or purchase of existing water rights is presently not recommended because there are only 19 acre-ft/yr (0.02 hm^3/yr) of approved ground-water rights (Woodburn and others, 1981) and 21 acre-ft/yr (0.03 hm^3/yr) of surface-water rights (DRI, 1980). These total less than one percent of the MX peak-water requirement for Dry Lake and Muleshoe valleys combined in 1984.

4.5.3 Suitable Areas for Water-Supply Well Locations

Two large areas in Dry Lake Valley have been identified as primary areas for development of the valley-fill aquifer (Drawing 4-5). In the northern part of the valley, there is an extensive primary area in the central valley and flanking alluvial fans. In the central and southern part of the valley, a 0.25- to 3-mile (0.4- to 5-km) wide strip of primary areas occurs between the lacustrine sediments in the valley floor and the edge of the valley. In Township 3S, these strips coalesce into one and extend southward into Delamar Valley.

The primary area for development of the valley-fill aquifer in Dry Lake Valley is extensive and is capable of providing well locations for the construction and operation of the MX missile system.

Due to the extensive deposition of lacustrine deposits in central and southern Dry Lake Valley, a large area is classified as secondary. This area extends from the north-central part of Township 1N to the central part of Township 3S and is 5 to 6 miles (8 to 10 km) wide.

Additional small secondary areas have been delineated on the western flank of the valley in Township 1S and on the southwest flank of the mountains in Township 3S. These areas are classified as secondary on the basis of geophysical and water-level data which indicate that only thin saturated thicknesses of valley-fill sediments occur. There is only one Air Force water-appropriation application point of diversion in the valley, and it lies in a secondary water-supply well development area at 3S-64E-12ac (number 40433).

There is only one cultural exclusion within the valley-floor area in Dry Lake Valley which is located in Township 1S near the east side of the valley. There are, however, four water-appropriation exclusions in the northern part of the valley floor and two water-appropriation exclusions in the central portion of the valley floor. These exclusions include the area within 1 mile (1.6 km) of an existing ground-water or surface-water appropriation. Other water-appropriation exclusions are found in the mountains adjacent to the valley. A possible regional spring occurs in Dry Lake Valley at 3N-65E-31cc.

4.5.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are three feasible MX water-supply alternatives for Dry Lake Valley. The alternative which can be ultimately used is largely dependent upon the decision of the State Engineer regarding temporary overdraft of the Dry Lake Valley ground-water basin. The three

alternatives, listed in order of priority from a technical standpoint, are discussed below.

4.5.4.1 Alternative I

The first alternative involves splitting the pending Air Force water-appropriation point of diversion at the existing Air Force test well at 3S-64E-12ca (number 40433) into multiple points of diversion, use of the existing test well at 3S-64E-12ca and the carbonate test well at 3N-63E-27cc, and the construction of two additional water-supply wells in the valley-fill aquifer. This approach will require the amendment of the pending application. This process should be initiated early in FY 82 to ensure that there is available water for the initial MX construction activities scheduled to begin in mid-1982.

The proposed LSC, presumed to be located in 3S-64E, will require from 230 to 1050 acre-ft/yr (0.28 to 1.29 hm^3/yr) with the peak requirement in 1986. Based upon an estimated well yield of 750 gpm (47 l/s), only one water-supply well will be required to deliver the 651 gpm (41 l/s) needed for peak water use at the LSC. The existing Air Force test well at 3S-64E-12ca has been pumped at a maximum rate of 750 gpm (47 l/s) and, if a sustained yield of 651 gpm (41 l/s) is possible, no additional MX water-supply wells will be required. During the period from 1983 to 1985, and during 1987, surplus water from the existing well could be utilized for DTN and cluster construction in the southern end of the valley.

The development of MX water-supply wells for DTN and cluster construction, operation, and reclamation will require the use of the existing Air Force valley-fill well at 3S-64E-12ca, the use of the existing carbonate exploration well at 3N-63E-27cc, and the construction of two additional MX water-supply wells.

In 1982 and 1983, the entire MX water requirement in Dry Lake Valley can be met through the operation of the existing Air Force valley-fill well. In 1984, however, the existing Air Force carbonate exploration well located at 3N-63E-27cc and three additional wells will be required to deliver the 3373 acre-feet (4.16 hm^3) which will be required. It is recommended that one additional valley-fill well be constructed in the primary area in the southern part of the valley and one valley-fill well be constructed in the primary area in the northern part of the valley. Assuming well yields of 650 gpm (41 l/s) or 1047 acre-ft/yr (1.29 hm^3/yr) if pumped continuously, these wells should be capable of supplying more than the MX water requirement (3373 acre-feet [4.16 hm^3]) during the peak-construction year. For the period from 1985 to 1986, the MX water requirements for nondomestic purposes decrease and a reduction in the pumping rates of the water-supply wells can occur.

4.5.4.2 Alternative II

If the State Engineer restricts MX ground-water withdrawal from the valley-fill aquifers of Dry Lake hydrographic basin (Dry Lake and Muleshoe valleys) to the perennial yield of 3000

acre-ft/yr (3.70 hm^3/yr) but allows additional water to be withdrawn from the carbonate aquifer, as much as 1341 acre-feet (1.65 hm^3) may have to be withdrawn from the carbonate aquifer in 1984. This alternative would then involve splitting the pending Air Force water-appropriation point of diversion at the existing Air Force test well at 3S-64E-12ca (number 40433) into multiple points of diversion, use of the existing valley-fill aquifer test well at 3S-64E-12ca, increasing the diameter of the carbonate aquifer test well at 3N-63E-27cc, and the construction of an additional valley-fill and carbonate aquifer well.

Although the carbonate test well at 3N-63E-27cc had a sustained yield of 106 gpm (7 l/s), the drawdown in the well was only 2 feet (0.6 m). Discharge from the well was limited by the greater than 800 feet (244 m) water depth and by small well diameter. A larger capacity pump, necessitating a larger diameter well, can be expected to increase the well yield to at least 450 gpm (28 l/s) or 725 acre-ft/yr (0.89 hm^3/yr) pumped continuously.

The entire MX water requirement in Dry Lake Valley can be met through the operation of the existing Air Force test well at 3S-64E-12ca in 1982, 1983, and 1987. In 1984, however, two carbonate wells, including the existing carbonate well at 3N-63E-27cc with an increased diameter, and one additional well in the valley-fill aquifer would be used to supply the required water. In 1985, most of the required water can be supplied by two wells tapping the valley-fill aquifer and only minimal water will be needed from a well in the carbonate aquifer. No water will be required from the carbonate aquifer in 1986.

4.5.4.3 General Well Characteristics

An Air Force well constructed in the valley-fill aquifer at 3S-64E-12ca (number 40433) was pumped at a constant discharge rate of 500 gpm (32 l/s), and results suggest that a higher sustained yield is possible. The valley-fill well was constructed with a 16-inch (41-cm) borehole and a 10-inch (25-cm) ID casing to a total depth of 1012 feet (308 m). Larger diameter wells may be capable of greater sustained yields if the same favorable aquifer is penetrated. Although the depth to water ranges from about 800 feet (244 m) below land surface in the northern part of the valley to over 300 feet (91 m) in the southernmost part of the valley, the depth to productive aquifer may be substantially greater. Therefore, it is recommended that MX water-supply wells be constructed to depths of at least 1200 feet (366 m). Due to the lack of hydrologic data for aquifer characteristics and well yields for much of Dry Lake Valley, it is recommended that exploratory drilling be conducted to verify the proposed locations of other MX water-supply wells.

4.5.5 Additional Investigations

Suggested possible sites for additional drilling and testing prior to operational development of the water-supply system are identified in Drawing 4-5.

An application was filed for only one point of diversion in Dry Lake Valley at 3S-64E-12ca (number 40433). The request for water at this point of diversion was sufficient to meet the peak MX water requirement for construction in the valley.

Two additional drilling sites have been identified beyond the application point of diversion in Dry Lake Valley. These sites were selected along existing roads in primary water-supply areas delineated in Drawing 4-5.

The drilling site located at 3N-64E-2ac in the northern part of the valley is the first priority. The site is located 3 miles (5 km) south of the proposed construction camp at the northern end of Dry Lake Valley. A well at this location could provide data on water quantity and quality, both of which will be necessary for planning domestic water supply at the construction camp. This site is also strategically located with respect to clusters and is approximately 1 mile (1.6 km) from the DTN in an area where little or no aquifer performance data exist.

The drilling site at 2N-64E-36cc is centrally located with respect to the DTN and the clusters. The site at 2N-64E-36cc in north-central Dry Lake Valley is approximately 12 miles (19 km) south of a proposed construction camp. Aquifer data within a 5-mile (8-km) radius are limited to one stock well.

4.6 ESCALANTE DESERT

4.6.1 Hydrologic Summary

Escalante Desert is an irregularly shaped, southwest-northeast trending valley encompassing parts of Beaver, Iron, Millard, and Washington counties in Utah. The valley consists of two hydrographic districts, Beryl and Milford, having a total area of approximately 4000 mi^2 (20,720 km^2) (Table 4-12).

The ground-water basin of Escalante Desert is reasonably well-developed and supports a large agricultural economy. There is a total of 163,700 acre-ft/yr (201.84 hm^3/yr) of certificated ground-water rights (Beryl-Enterprise District Water Commissioner, 1979; and Milford District Water Commissioner, 1979). The perennial yield of the Beryl District is estimated by Ertec to be 30,000 acre-feet (36.99 hm^3) and the Milford district is estimated to be 33,000 acre-feet (40.69 hm^3) or a combined total of 63,000 acre-ft/yr (77.68 hm^3/yr). The volume of recoverable water in storage within the upper 100 feet (30 m) of saturated sediment is estimated at 12.6 million acre-feet (15,535.8 hm^3) (Ertec, 1981). With ground-water overdraft running at 76,750 acre-ft/yr (94.63 hm^3/yr), 28,300 acre-ft/yr (34.89 hm^3/yr) in Milford, and 48,450 acre-ft/yr (59.74 hm^3/yr) in Beryl (Ertec, 1981), the basin is closed to additional ground-water appropriations by the Utah State Engineer.

The results of the tests conducted by Ertec in Escalante Desert indicate that the valley-fill aquifer is generally unconfined especially along the valley margins, but there is also some

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg. Valley Width	Suitable Area	Avg. Valley Floor Elevation
4000 sq mi	100 mi	40 mi	OB SITE	5500 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	30-200 ft	50[illegible]-5150 ft	10,[illegible]	0.[illegible]2

Perennial Yield	Ground-Water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
30,000	2000	27,100	0	30,[illegible]	4000

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds (1) Standards	Suitable for Construction	Exceeds (2) Standards
28	27	1	27	.

WATER USE AND APPROPRIATIONS

Source	Current Use	Permits	Certificates	[illegible] (3)
Ground Water	78,450	_	1[illegible]8,200 [illegible]	_
Surface Water	8000	_	Unknown	–

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction		34	2[illegible]4	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Operation									

Milford and Beryl combined
Three analyses exceed recommended limit of TDS [illegible] the maximum limit
Perennial yield − Current use [illegible] Perennial yield − Certificated Use
No additional applications are being considered
Claims of all types [illegible] permits [illegible]

Note: All units are in acre-feet per year unless otherwise noted

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HYDROLOGIC SUMMARY ESCALANTE DESERT—BERYL, NEVADA

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GENERAL PHYSIOGRAPHY

Valley Area*	Valley Length*	Avg. Valley Width	Suitable Area	Avg. Valley Floor Elevation
4000 sq mi	100 mi	40 mi	OB SITE	4840 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	30-150 ft	4950-5100 ft	5900 sq ft day	0.008

Perennial Yield	Ground-Water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
32,000	1300	16,700	0	22,700	25,390

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds (1) Standards	Suitable for Construction	Exceeds (2) Standards
40	32	7	35	5

WATER USE AND APPROPRIATIONS

Source	Current Use	Permits	Certificates/Proofs	Availability(3)
Ground Water	60,000	_	55,500	_
Surface Water	25,100	_	20,780	_

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction Operation		24	254	[illegible]	[illegible]	[illegible]	[illegible]	1399	970

* Beryl and Milford combined
(1) Exceeds (USPHS) standards as follows: 1 - nitrate, 2 - fluoride, 6 - sulfate, 5 - TDS
(2) Exceeds TDS criteria level
(3) No additional appropriations are available

Note: All units are in acre-feet per year unless otherwise noted.

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ESCALANTE DESERT—MILFORD, NEVADA
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indication of localized occurrence of semiconfined and confined conditions due to the presence of lacustrine clays. Aquifer tests conducted by Ertec of Air Force test wells in both Milford and Beryl districts give transmissivity values of 3400 to 13,000 ft^2/day (316 to 1208 m^2/day) and an estimated storativity of 0.08.

There are four perennial streams in Escalante Desert. These are Shoal, Pinto, and Meadow creeks in Beryl district and the Beaver River in the Milford district. All other streams entering Escalante Desert are ephemeral and flow only in response to heavy precipitation or during periods of active snowmelt. A complete listing of surface-water appropriations is not available at this time (September 1981), but it is known that the available surface-water supply is fully utilized.

Chemical analyses of ground water from 38 wells and two springs in the Milford district and from 22 wells and six springs in the Beryl district performed by Ertec were used to evaluate the water quality in Escalante Desert. Additional water-quality data from other sources, USGS (1976, 1978, 1979a, 1979b, 1980), Mower and Cordova (1976), and Sandberg (1966), were used to assess the suitability of the ground-water for domestic and construction use. From a water-quality viewpoint, development of water resources for OB use should be away from high agricultural use areas. Ground-water samples in these areas meet both federal and state drinking water standards for all inorganic constituents tested.

4.6.2 Water-Supply Sources

The lease or purchase of water from existing owners is the preferred water-supply source for the proposed OBs in Escalante Desert (Table 4-13). Present ground-water diversions in the Beryl District far exceed the perennial yield, and an overdraft of 48,450 acre-ft/yr (59.74 hm^3/yr) is estimated by Ertec to be occurring. In the Milford area, an overdraft of ground water totaling 28,300 acre-ft/yr (34.89 hm^3) is estimated by Ertec to be occurring. As a result, the State Engineer of Utah will not allow new appropriation of ground water at either the Beryl or Milford candidate OB site. This means that new development of the valley-fill aquifer is excluded from consideration. The lease or purchase of existing ground-water rights is the least costly of the viable options.

Snake Valley is the nearest valley where water is plentiful and could be imported for use at either the Beryl or Milford candidate OB sites. Importation of water over distances of approximately 56 miles (90 km) would be extremely costly (70 times more costly than the valley-fill option) and would take over a year to construct. This does not include the time required to obtain environmental clearances for such a conveyance system. Also, the viewpoints of the Nevada and Utah State Engineers toward transporting water out of a valley which is administered by both states has not been clarified. The carbonate aquifer in the proposed Milford OB area has little development potential and there are no known suitable carbonate aquifer sites in the proposed Beryl OB area. Also, the Utah State Engineer may not

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Criteria	Weight	Valley Fill Aquifer Score	Valley Fill Aquifer Wt Score	Carbonate Aquifer Score	Carbonate Aquifer Wt. Score	Lease/ Purchase Score	Lease/ Purchase Wt. Score	Importation Score	Importation Wt. Score
Legal Water Availability	10	0	0	0	0	10	100	8	80
Impacts on Man or Environment	10	[illegible]	[illegible]	10	100	7	70	5	50
Development Potential (Physical Availability)	10	10	100	1	10	10	100	10	100
Cost	4	10	40	2	8	1	4	0	0
Timeliness	6	10	60	1	6	10	60	0	0
Water Quality	2	10	20	10	20	10	20	10	20
Final Weighted Score			298 [1]		130		372 *		250 +

* Recommended source of water supply

\+ First alternative source of water supply

1 Valley fill aquifer development is not the first alternative source of water supply because the Utah State Engineer will not allow additional ground water appropriations in Escalante Desert.

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WATER-SUPPLY SOURCE MATRIX
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TABLE 4-13

allow new long-term appropriations of ground water from the carbonate aquifer because of the present overdraft situation in the valley-fill aquifer. Development of the carbonate aquifer would also take eight times longer than lease or purchase of existing water rights or valley-fill aquifer development.

4.6.3 Suitable Areas for Water-Supply Well Locations

Primary areas for well locations in Escalante Desert lie within boundaries which are approximately 6 miles (10 km) from all proposed OB locations and OBTS locations. The primary areas primarily reflect the limits of cultural and water-appropriation exclusions. Secondary areas were not delineated in Escalante Desert because detailed surficial geologic maps and gravity survey data that are used in the determination of these areas are not available.

Greater than 60 mi^2 (155 km^2) of primary area have been delineated in Escalante Desert. An additional area of about 40 mi^2 (104 km^2) in southern Hamlin Valley north of the proposed Beryl OBTS has also been identified (within a 6-mile [10-km] radius).

Within the approximate boundaries of the proposed Beryl OB location, about 6 mi^2 (16 km^2) of suitable area occur. Two relatively large suitable areas lie adjacent to the Beryl preferred OBTS 14 mi^2 (36 km^2) in (C-33-15) and 15 mi^2 (39 km^2) in (C-35-13).

There is very little suitable area (less than 10 mi^2 [26 km^2]) adjacent to either of the proposed Milford OB locations or the

alternate test site location. However, greater than 25 mi^2 [65 km^2]) of suitable area lie adjacent to or within the boundaries of the Milford preferred OB test site.

Extensive areas of cultural and ground water exclusion occur within the valley. Surface-water appropriation exclusion areas with the exception of spring locations, are not shown in Drawing 4-6 because the information was not available.

4.6.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are two viable MX water-supply systems alternatives for the AOB proposed for either the Milford or Beryl districts in Escalante Desert, Utah. Each of these alternatives is discussed below in order of priority.

4.6.4.1 Alternative I

The first alternative MX water-supply system for the AOB consists of the lease or purchase of existing water rights, the transfer of these water rights to suitable areas in or adjacent to the proposed AOB sites, and the construction of eight water-supply wells. This is in addition to the existing Air Force test well, if the AOB is located in the Milford District, or four wells in addition to the existing Air Force test well, if the AOB is located in the Beryl district.

The principal advantage of this approach is that a well distributed well field would be availalbe for the construction and operation of the AOB. The principal disadvantages are that

at least four additional MX water-supply wells would be required, and it will be necessary to identify and lease or purchase selected existing water rights and go through the legal process of transferring the points of diversion to a more convenient location for water supply.

Life Support Camp

The proposed LSC, presumed to be in (C-31-12) and (C-32-12) for the Milford alternative or in (C-33-18) and (C-33-17) for the Beryl alternative, will require from 2000 to 2866 acre-ft/yr (2.45 to 3.53 hm^3/yr) with the peak-year demand occurring in 1988. Assuming a well yield of 350 gpm (22 l/s) for the Milford District and 600 gpm for the Beryl District, based on Ertec aquifer test results, the number of wells required to supply the LSC water demand is as follows:

NUMBER OF WATER-SUPPLY WELLS REQUIRED

Year	Milford District	Beryl District
1985	4	3
1986	4	3
1987	5	3
1988	5	3
1989	5	3

Both alternative AOB locations have adequate primary areas for the location of MX water-supply wells.

Other AOB Facilities

The AOB will require water for revegetation, dust control, road construction, and landscaping. Assuming the same well yields as for the LSC water requirement, the number of water-supply

needed for nondomestic purposes at the proposed AOB sites is as follows:

NUMBER OF WATER-SUPPLY WELLS REQUIRED*

Year	Milford District	Beryl District
1983	0	0
1984	0	0
1985	4	1
1986	2	1
1987	0	0
1988	2	1
1989	2	1
1990	0	0

* Includes surplus pumpage from wells primarily for LSC water use.

Therefore, the total number of water-supply wells required for the LSC and other AOB facilities is:

NUMBER OF WATER-SUPPLY WELLS REQUIRED

Year	Milford District	Beryl District
1983	0	0
1984	0	0
1985	8	4
1986	6	4
1987	5	3
1988	7	4
1989	7	4
1990	5	3

4.6.4.2 Alternative II

The second alternative MX water-supply system for the AOB consists of the lease or purchase of existing water rights and the transfer of only enough rights to the existing Air Force

test well to satisfy the withdrawal rates for that well. For the remainder of the MX water requirement, the location of the original point of diversion would remain the same and the water would be leased. The advantages of this approach are that the need for four to eight additional MX water-supply wells would be eliminated and only the one change in existing point of diversion to the existing Air Force test well would be subject to the publication, protest, and hearing process. The primary disadvantage is that an extensive pipeline and pumping station system would be required to transport the water from the place of purchase to the place of use.

The lease or purchase of water for AOB construction and operation can be derived from either agricultural or mining interests in Escalante Desert. If water is purchased from the agricultural interests, it will be necessary to remove about 1680 acres (680 ha) of land from cultivation (Ertec, 1981).

4.6.4.3 General Well Characteristics

Based upon the results of aquifer tests conducted by Ertec, well yields of 350 gpm (22 l/s) are possible at the Milford AOB site and 600 gpm (38 l/s) at the Beryl AOB site. The Air Force test wells were constructed to depths of 353 feet (108 m) in the Beryl District and 500 feet (152 m) in the Milford District and both wells have 10-inch (25-cm) ID casing. It may be possible to increase the well yields obtained through the use of larger diameter boreholes (18 to 24 inches [46 to 61 cm]) and ID casings (12 to 18 inches [30 to 46]). Due to the presence of

thick, continuous clays beneath the test wells, it is not believed that greater well yields can be obtained through greater drilling depths. Therefore, it is recommended that any additional MX water-supply wells be drilled to depths not in excess of 500 feet (152 m).

4.6.5 Additional Investigations

The Utah State Engineer has determined that no additional ground-water appropriations be considered in the Escalante Desert at this time. For this reason, there are no pending Air Force points of diversion to consider as potential additional drilling and testing sites. The Air Force test well located within the Beryl AOB boundary at (C-33-17)21dd has been tested by Ertec and the data evaluated to provide information concerning the characteristics of the valley-fill aquifer in this area. The second Air Force test well is located between the two Milford AOB options at (C-31-13)5bb. This well has been tested by Ertec and the data evaluated to provide aquifer performance data for this area of the Escalante Desert. These aquifer performance data combined with existing well logs indicate relatively uniform aquifer conditions throughout the area of the Milford and Beryl AOB options. Therefore, additional drilling and investigation in advance of operational development of the water-supply system is unnecessary.

4.7 GARDEN VALLEY

4.7.1 Hydrologic Summary

Garden Valley is a topographically open basin located in Lincoln and Nye counties, Nevada. Of the 508 mi^2 (1315 km^2) of valley area, 200 mi^2 (518 km^2) are suitable for MX deployment (Table 4-14).

Ground water in Garden Valley is largely undeveloped. There are 91 acre-feet (0.12 hm^3) of current ground-water diversions (DRI, 1980) and 370 acre-ft/yr (0.46 hm^3/yr) in certificated and permitted water rights (Woodburn and others, 1981). In addition, there are 7060 acre-ft/yr (8.70 hm^3/yr) of pending applications for ground-water withdrawal in the valley which were filed prior to Air Force applications.

The perennial yield of the basin is estimated at 6000 acre-ft/yr (7.40 hm^3/yr) (State of Nevada, 1971). Ground water in storage in the upper 100 feet (30 m) of saturated sediment is estimated at 1.5 million acre-feet (1849.5 hm^3) (State of Nevada, 1971). Ground-water availability is well in excess of the peak-year MX water requirement of 1508 acre-feet (1.86 hm^3) in 1984 unless a significant portion of the 7060 acre-ft/yr (8.70 hm^3/yr) of pending non-Air Force appropriation applications are approved and withdrawal starts prior to 1987, the last year of MX withdrawal of water for construction.

Based on examination of drilling logs and an Air Force aquifer test, the valley-fill aquifer in Garden Valley appears to be

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg Valley Width	Suitable Area	Avg Valley Floor Elevation
508 sq mi	50 mi	10 mi	200 sq mi	5100-6200 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-Fill	25-550 ft	[illegible]-5400 ft	[illegible] sq ft/day	0.005

Perennial Yield	Ground Water Recharge (afy)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
[illegible]	13,000	0	[illegible]	[illegible]	1800

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds Standards *	Suitable for Construction	Exceeds Standards **
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

WATER USE AND APPROPRIATIONS

Source	Current Use	Applications	Permits	Availability
Ground Water	[illegible]	[illegible]	[illegible]	[illegible]
Surface Water	[illegible]	[illegible]	[illegible]	[illegible]

MX WATER REQUIREMENTS

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

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HYDROLOGIC SUMMARY
GARDEN VALLEY, NEVADA

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TABLE 4-14

generally unconfined. Lacustrine clays may exist in the valley and could produce locally confined or semiconfined conditions. The depth to water ranges from about 25 feet (8 m) in the northern part of the valley to about 550 feet (168 m) in the south. Data from the aquifer test performed by Ertec in the valley-fill sediments (2N-57E-22ba) indicate a transmissivity of 12,000 ft^2/day (115 m^2/day) and a minimum storativity of 0.003. A well yield of 500 gpm (32 l/s) was maintained for 30 days.

Surface stream flow is intermittent, and spring discharge does not represent a significant or dependable water source in the valley.

Chemical analyses of water samples from the valley-fill aquifer and local springs indicate that the quality of ground-water is within the criteria establisned for construction and within primary and secondary drinking water standards established by the State of Nevada (Appendix D).

4.7.2 Water-Supply Sources

Development of the valley-fill aquifer is the preferred MX water-supply source in Garden Valley (Table 4-15). This supply source is estimated to be the least costly and the most timely to develop. The perennial yield of Garden Valley has been estimated by the State of Nevada (1971) to be 6000 acre-ft/yr (7.40 hm^3/yr). The quantity of ground water presently available for development is about 5630 acre-ft/yr (6.94 hm^3/yr) based on existing approved ground-water rights and 5909 acre-ft/yr

Criteria	Weight	Valley Fill Aquifer		Carbonate Aquifer		Lease/ Purchase		Importation	
		Score	Wt. Score	Score	Wt. Score	Score	Wt Score	Score	Wt. Score
Legal Water Availability	10	10	100	10	100	4	40	8	80
Impacts on Man or Environment	10	8	80	8	80	7	70	4	40
Development Potential (Physical Availability)	10	4	40	7	70	4	40	10	100
Cost	4	10	40	3	12	9	36	2	8
Timeliness	6	10	60	2	12	8	48	1	6
Water Quality	2	10	20	10	20	10	20	10	20
Final Weighted Score			[illegible] *		294 +		254		254

* Recommended [illegible] supply

\+ First alternative [illegible] supply

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WATER-SUPPLY SOURCE MATRIX
GARDEN VALLEY, NEVADA

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TABLE 4-18

(7.29 hm^3/yr) based on present ground-water diversions. These quantities of water are large compared to the peak-year MX requirement of 1508 acre-feet (1.86 hm^3) in 1984. There are, however, 7060 acre-ft/yr (8.70 hm^3/yr) of pending ground-water applications in the valley. If most of these applications were approved by the State Engineer prior to consideration of MX applications, then an alternative source of water supply may be required.

Development of the carbonate aquifer in Garden Valley ranked second overall because of a high legal availability and moderately high physical availability. Carbonate aquifer development however, is estimated to cost about three times that of the valley-fill aquifer and take up to four times as long to construct.

Importation of water is ranked third, although it has the same score as the lease/purchase option. High costs and time would be required to develop this source. Construction of pipelines from a source valley (Railroad) and installation of pumping stations are estimated to cost about five times as much and take 16 times as long to construct as development of the valley-fill aquifer.

Lease or purchase of existing water rights is not considered a viable option because only about one-third of the peak-year MX water requirement can be supplied through existing approved ground-water rights and present surface-water use. Only if a

significant portion of the pending applications for ground-water withdrawal in the valley were approved in the near future by the State Engineer would this become a viable water-supply option.

4.7.3 Suitable Areas for Water-Supply Well Locations

The primary and secondary areas for the location of valley-fill wells in Garden Valley, Nevada, are shown in Drawing 4-2.

A large primary area has been delineated in the central portion of Garden Valley. This area extends from Township 1S to Township 5N and occupies an area of over 100 mi^2 (259 km^2). A smaller area in Township 2S of about 5 mi^2 (13 km^2) has also been identified, however, available geophysical and water-level data are limited in this area and ground-water conditions are unconfined. The available primary area in Garden Valley is extensive and capable of providing a number of adequate well locations for MX construction and operation activities. Six of the eight Air Force water appropriation applications points of diversion lie within primary water-supply well development areas. These are located at 1N-57E-23bb (number 41711), 2N-57E-29dd (number 41716), 2N-57E-24bd (number 41714), 2N-57E-15ac (number 41715), 3N-58E-8ab (number 41718), and 2N-57E-3aa (number 41713).

Based upon the interpretation of available geophysical and water-level data, three secondary areas have been delineated in Garden Valley where saturated thicknesses of valley-fill material are estimated to be less than 200 feet (61 m) and small

well yields are likely. Another area on the eastern side of the valley in Township 3N has been classified as secondary due to lacustrine deposits. Sediments in this area are of presumed low permeability and ground water may be of poor quality. Only one Air Force water appropriation application point of diversion is located within a secondary area for water-supply well development, application number 41717 at 1S-58E-18bc.

Two cultural exclusion areas occur in Garden Valley. An area of about 15 mi^2 (39 km^2) in the northwest part of the valley lies within the boundaries of the Humboldt National Forest and a fee-land exclusion area of about 2 mi^2 (5 km^2) occurs in Township 2N in the west-central part of the valley. Sixteen existing wells or ground-water appropriation exclusion areas occur in Garden Valley; 11 lie in the northern part of the valley, four in the central part, and one in the southern part. In addition, two surface-water appropriation exclusion areas (a 1-mile [1.6-km] radius from the point of diversion or spring location) occur in the north and central part of the valley. There are no known regional or possible regional springs within Garden Valley. One Air Force appropriation application point of diversion lies in an excluded water-supply well development area at 2N-58E-2da (number 41712).

4.7.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are two viable MX water-supply system alternatives for Garden Valley. A

description of both alternatives is provided below. The alternatives are listed in order of priority.

4.7.4.1 Alternative I

This alternative emphasizes development of the valley-fill aquifer and consists of the construction of one additional MX water-supply well at one of the eight pending points of diversion filed with the Air Force water-appropriation application and the amendment of two points of diversion from their existing location to the Air Force valley-fill test well at 2N-57e-22ba and the Air Force carbonate test well at 3N-59E-10bc.

There is no LSC scheduled for Garden Valley. In 1983, the 287 acre-feet (0.35 hm^3) of water required for DTN and cluster construction can be met through pumpage of the existing Air Force test well located at 2N-57E-22ba. This well is capable of supplying 884 acre-feet (1.09 hm^3) per year based on its proven pumping rate of 517 gpm (33 l/s).

In 1984, the MX water requirement peaks at 1508 acre-feet (1.86 hm^3), and an additional well will be required. The pending point of diversion located at 3N-58E-8ab (number 41718) is located in a primary area and could provide water for DTN and cluster construction activities in the northern and eastern part of the valley. If the estimated well yield at this point of diversion (500 gpm [31.5 l/s]) is correct, this well and the existing Air Force valley-fill test well will be capable of supplying the peak-year MX water requirement. The Air Force

carbonate test well at 3N-59E-10bc is capable of supplying an additional 161 acre-ft/yr (0.20 hm^3/ yr) at a pumping rate of 100 gpm (7 l/s).

In 1985 through 1987, the entire MX water requirement could be met through pumpage of the existing Air Force valley-fill test well. It may be preferable, however, to keep both valley-fill wells and the carbonate well in operation at reduced pumping rates.

The principal advantage of this alternative is that it would require the construction of only one additional valley-fill aquifer well. The principal disadvantage is that the amendment of two pending points of diversion would be required.

4.7.4.2 Alternative II

This alternative emphasizes development of the regional carbonate aquifer and consists of use of the Air Force carbonate test well at 3N-59E-10bc, use of the existing Air Force valley-fill test well at 2N-57E-22ba, and development of one additional carbonate well. Two of the Air Force's eight pending points of diversion would have to be amended from their existing location to the location of the Air Force valley-fill test well and the location of the new carbonate well.

The 287 acre-feet (0.35 hm^3) of water required for DTN and cluster construction in 1983 can be met through pumping of the existing Air Force valley-fill and carbonate test wells. Although the valley-fill well is capable of meeting the entire

demand, both wells should be used to provide a better distributed water supply.

To meet the peak water requirement of 1508 acre-feet (1.86 hm^3) in 1984, a second carbonate well will be required. Although the existing carbonate test well is capable of only limited production, geologic conditions in Garden Valley are indicative of significant potential for water development in the carbonate rocks. A well yield in excess of the 300 to 400 gpm (19 to 25 l/s) required to meet MX demand should be possible with careful selection of the drilling site.

During the period 1985 to 1987, the entire MX water requirement could be met through pumping of either the valley-fill test well or the second carbonate well. In practice, it may be preferable to pump all existing wells to maintain a distribution of water supply.

The principal disadvantage of this alternative as compared to development of the valley-fill aquifer is the higher cost and the greater potential for drilling a nonproductive well (risk factor).

4.7.4.3 General Well Characteristics

The Air Force test well constructed in the valley-fill aquifer at 2N-57E-22ba was tested at a constant discharge rate of 517 gpm (33.6 l/s). The exploratory carbonate aquifer well located at 3N-59E-10bc is capable of producing only about 100 gpm (6 l/s). The valley-fill test well was constructed with a 16-inch

(41-cm) borehole and a 10-inch (25-cm) ID casing to a total depth of 1065 feet (325 m). Larger diameter wells may be capable of greater sustained yields if the same favorable aquifers are penetrated. Although the depth to water ranges from about 25 feet (8 m) below land surface in the northern portion of the valley to over 550 feet (168 m) in the southernmost part of the valley, the depth to productive aquifers may be substantially greater. It is recommended that MX valley-fill, water-supply wells be constructed to depths of at least 1200 feet (152 m) in the southern part and 500 feet (15 m) in the northern part of the valley.

It is recommended that carbonate aquifer wells be constructed to depths of at least 1835 feet (5590 m) with design characteristics similar to those described in Section 3.3.1.

4.7.5 Additional Investigations

Suggested sites for additional drilling and testing prior to development of the MX water-supply system in Garden Valley are identified in Drawing 4-2 and are ranked in Table 4-16. The Air Force test well located at 2N-57E-22ba in west-central Garden Valley has been tested and the data evaluated to provide information concerning the valley-fill aquifer.

A pending Air Force point of diversion, number 41718, is located at 3N-58E-8ab in the northwestern part of the valley and is recommended for additional drilling. This site is in an area where little information concerning aquifer performance is

CRITERIA	POINTS OF DIVERSION						
		41714 2N-57E-24bd		41715 2N-57E-15ac		41713 2N-57E-3aa	
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	4	20	4	20	4	20
Proximity to Const. Camp or Plant	6	0	0	0	0	0	0
Proximity to DTN or Cluster	4	8	32	7	28	6	24
Sparse Data Area	10	2	20	2	20	6	60
Final Weighted Score			72		68		104

* Recommended additional drilling site(s) at points of diversion

Note : Air Force test and observation wells located 1 1/4 miles from point of diversion number 41715

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ADDITIONAL DRILLING/TESTING
SITE MATRIX
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TABLE 4-16

CRITERIA	POINTS OF DIVERSION						
		41718 3N-58E-8ab					
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	4	20				
Proximity to Const. Camp or Plant	6	0	0				
Proximity to DTN or Cluster	4	6	24				
Sparse Data Area	10	5	50				
Final Weighted Score			94 *				

* Recommended additional drilling site(s) at points of diversion

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ADDITIONAL DRILLING/TESTING
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TABLE 4-16

CRITERIA	POINTS OF DIVERSION						
		41717 1S-58E-18bc		41711 1N-57E-23bb		41716 2N-57E-29dd	
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	3	15	3	15	3	15
Proximity to Const. Camp or Plant	6	0	0	0	0	0	0
Proximity to DTN or Cluster	4	4	16	5	20	5	20
Sparse Data Area	10	6	60	6	60	2	20
Final Weighted Score			91		95		55

* Recommended additional drilling site(s) at points of diversion

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ADDITIONAL DRILLING/TESTING
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TABLE 4-16

available. One irrigation well and one stock well are located between 3 and 5 miles (5 and 8 km) of the site. One stock well is located within 2 miles (3 km) of the site. This site is positioned well with respect to clusters should it be utilized as an MX water-supply source.

Pending Air Force point of diversion number 41712, although showing a high score, is not recommended for testing because of its relative proximity to the existing Air Force valley-fill test well.

4.8 HAMLIN VALLEY

4.8.1 Hydrologic Summary

Hamlin Valley is a north-south trending basin encompassing parts of Lincoln and White Pine counties, Nevada, and Millard, Beaver, and Iron counties, Utah. It is a topographically open basin and is hydrologically connected to Snake and Spring valleys to the north. The northern boundary of Hamlin Valley was defined based on cultural and geotechnical criteria rather than the hydrographic boundary between Hamlin and Snake valleys. As defined, the drainage basin is about 84 miles (135 km) long and 16 miles (27 km) wide, resulting in a total area of 1360 mi^2 (3522 km^2) of which 335 mi^2 (868 km^2) are suitable for MX deployment (Table 4-17). Hamlin Valley straddles the Nevada-Utah state line and its water resources are subject to the jurisdiction of both the Nevada and Utah State Engineers.

Ground water is primarily developed in the northern portion of Hamlin Valley. There are 3504 acre-ft/yr (4.32 hm^3/yr) of certificates and proofs of ground-water rights and there are 31,136 acre-ft/yr (38.40 hm^3/yr) of permits and pending applications (DRI, 1980). The combined perennial yield for the Snake-Hamlin hydrographic basins has been estimated by the U.S. Geological Survey (1979) to be 74,000 acre-ft/yr (91.24 hm^3/yr). The perennial yield for Hamlin Valley as delineated for this study is estimated by Ertec to be 25,000 acre-ft/yr (30.82 hm^3/yr). Ground water in storage within the upper 100 feet (31 m) of saturated sediment in Hamlin hydrographic basin only is estimated at 1.2 million acre-ft/yr (1479.6 hm^3) (State of Nevada,

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg Valley Width	Suitable Area	Avg Valley Floor Elevation
1560 sq mi	84 mi	16 mi	335 sq mi	5225-6400 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill Carbonate	[illegible]-300 ft	[illegible] ft	2500 sq ft/day	0.01

Perennial Yield	Ground-water Recharge (100%)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
25,000	26,500	4000	25,500	7000	–

WATER QUALITY

Total Samples	Suitable For Consumption	Exceeds * Standards	Suitable For Construction	Exceeds ** Standards
14	14	0	14	0

WATER USE AND APPROPRIATIONS

Source	Current Use	Applications/ Permits	Certificated Rights	Availability[1]
Ground Water	–	[illegible]	[illegible]	–
Surface Water	17,280	[illegible]	17,280	–

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Operation									

* Perennial Yield – Current Use / Perennial Yield – Certificated Use
** State and Federal Drinking Water Standards
*** Portland Cement Association [illegible]

Note: All units are in acre-feet per year unless otherwise noted

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HYDROLOGIC SUMMARY
HAMLIN VALLEY, UTAH AND NEVADA

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TABLE 4-17

1971). It is anticipated that withdrawal of even the peak-year MX water requirement of 2620 acre-feet (3.23 hm^3) in 1984 would be within the quantity of perennial yield available, and only a very small portion of the ground water in storage, unless a significant portion of the pending appropriations is approved and withdrawal starts prior to 1989, the last year MX withdrawals for construction are expected.

Data from aquifer tests and lithologic logs indicate the presence of a largely unconfined valley-fill aquifer in Hamlin Valley, although lacustrine clays may produce locally confined or semiconfined conditions. An aquifer pump test conducted by Ertec at 8N-69E-35dc indicates an average transmissivity of the valley-fill aquifer is on the order of 2500 ft^2/day (23 m^2/day), and the storativity is approximately 0.01. Although wells have not been completed in the carbonate rocks in Hamlin Valley as part of Ertec's carbonate studies program, the potential for development of a carbonate aquifer in the area is rated high. Rating is based on a number of criteria including the thickness of lower Paleozoic carbonate rocks in the area, relatively high density of faulting, and the absence of thick sequences of volcanic rocks. The high rating in Hamlin Valley is enhanced by the occurrence of Big Spring (10-70E-33abc) which discharges from carbonate rocks in the northwestern portion of the valley.

Surface water in most of Hamlin Valley is nearly or totally appropriated and utilized. Perennial streams include Baker, Lehman, and Snake creeks. Big Spring is the only major spring in the valley.

Water samples collected by Ertec from 14 spring, stream, and well locations in Hamlin Valley were chemically analyzed. All of the samples satisfied water-quality criteria for construction and drinking water use.

4.8.2 Water-Supply Sources

The acquisition of new permits and the construction of conventional water wells in the valley-fill aquifer is the preferred MX water-supply source in Hamlin Valley (Table 4-18). The perennial yield of Hamlin Valley is estimated by Ertec to be 25,000 acre-feet (30.82 hm^3), however, most of the ground-water recharge and use is located in the extreme northern portion of the valley (southern portion of Snake hydrographic basin). Approximately 5000 acre-feet (6.16 hm^3) of perennial yield is estimated (State of Nevada, 1971) for the portion of Hamlin Valley which is considered suitable for MX siting. The quantity of ground water presently undiverted in this area of Hamlin Valley is 4148 acre-ft/yr (5.11 hm^3/yr) (DRI, 1980; and UWRL, 1980). The amount of approved ground-water rights have not been determined. The quantity of undiverted ground water is sufficient to supply the 2620 acre-feet (3.23 hm^3) peak-year water requirement for MX construction in 1984. The aquifer test conducted by Ertec indicates that the valley-fill aquifer has a moderately high physical potential for development and the legal availability is also high.

Development of the carbonate aquifer was ranked second among the alternatives because it is rated as having a high physical

Criteria	Weight	Valley-fill Aquifer Score	Valley-fill Aquifer Wt. Score	Carbonate Aquifer Score	Carbonate Aquifer Wt Score	Lease/ Purchase Score	Lease/ Purchase Wt Score	Importation Score	Importation Wt. Score
Legal Water Availability	10[1]	10	100[2]	10	100[2]	2[1]	20	8	80
Impacts on Man or Environment	10	6	60	5	50	[illegible]	70	5	50
Development Potential (Physical Availability)	10	8	80	9	90	8	80	10	100
Cost	4	10	40	2	8	5	20	1	4
Timeliness	6	10	60	2	12	10	60	2	12
Water Quality	2	10	20	10	20	10	20	10	20
Final Weighted Score			[illegible] *		280 +		270		266

1 Does not include permits
2 Includes Snake / Hamlin area
* Recommended source of water supply
\+ First alternative source of water supply

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WATER-SUPPLY SOURCE MATRIX
HAMLIN VALLEY, UTAH AND NEVADA

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TABLE 4-18

potential for development. However, it is rated lower than valley-fill aquifer development because of the high cost (five times the valley-fill option) and the time (four times the valley-fill option) required to develop the source.

The third-ranked, water-supply source is lease or purchase of existing water rights. Within the area delineated as Hamlin Valley, approved surface water rights total at least 17,280 acre-ft/yr (21.31 hm^3/yr) (DRI, 1980). These are from dependable spring and creek sources located primarily in the northern portion of the valley. Approved ground-water rights total at least 3504 acre-ft/yr (4.32 hm^3/yr) (DRI, 1980). Lease or purchase of water rights would be about two times more costly than acquiring new permits and developing the valley-fill aquifer and would not provide a significant time benefit. Nevertheless, lease or purchase of existing water rights would have the least impact potential on the local water users and the environment.

Importation of water was ranked the lowest of the four water-supply alternatives, although it scored essentially the same as lease/purchase, because it was estimated to be the most costly of the four options and requires a relatively long time to construct. Importation of water from nearby Snake and Spring valleys is feasible; however, the viewpoint of the Nevada and Utah State Engineers' office toward transportation of water from one basin to another, and across state lines, may be unfavorable.

4.8.3 Suitable Areas for Water Supply Well Locations

The primary and secondary areas for the construction of MX water-supply wells in Hamlin Valley are shown in Drawing 4-8.

Five primary areas have been identified in Hamlin Valley. In the northern part of the valley, a small primary area of about 6 mi^2 (16 km^2) occurs in Township 11N. In central Hamlin Valley, three primary areas occur along the eastern and western valley flanks separated by valley-floor lacustrine deposits. A large area of about 30 mi^2 (78 km^2) occurs along the western flank, and two other areas comprising about 25 mi^2 (65 km^2) occur along the eastern flank. In the southern part of the valley, a large area, approximately 100 mi^2 (259 km^2), is classified as primary. Although the amount of primary area in the northern and central portion of Hamlin Valley is not as great as in the southern portion, there are sufficient primary areas throughout the valley that could be used as ground-water supply locations for the construction and operation of the MX missile system in the valley. Two of the five Air Force applications for ground-water rights lie within primary areas for water-supply well development. These are application numbers 41721 at 9N-69E-15aa and 55022-1 at (C-31-18) 33dd.

Due to extensive deposition of lacustrine and playa sediments in northern and central Hamlin Valley, a large area, greater than 100 mi^2 (259 km^2), is classified as secondary and extends from Township 11N to Township 6N. The sediments in this area are of low permeability and ground water within these deposits

may be of poor quality. Based upon the interpretation of available geophysical and water-level data, two other secondary areas have been delineated, an area of about 10 mi^2 (26 km^2) in Township 11N and a larger area of about 40 mi^2 (104 km^2) in central and southern Hamlin Valley. Two of the five Air Force water-appropriation applications lie in secondary areas for water-supply well development, one at 8N-69E-35da (number 41720) and one at 6N-70E-13dd (number 41719).

A number of 0.5 mi^2 and 1 mi^2 (1.3 and 2.6 km^2) state land cultural exclusions occur east of the Utah State Line throughout Hamlin Valley. A total of about 30 mi^2 (78 km^2) of fee-land exclusions occur mainly in northern Hamlin Valley in Townships 10N and 11N and at the extreme southern end of the valley. Two other areas in southern Hamlin, within a 1-mile (1.6-km) radius of where rare plant species have been found, are also excluded. A total of 17 existing wells or ground-water appropriations have been identified as exclusion areas. Eight of these are located in the northern part of the valley, seven in the central part, and two in the southern part. In addition, two springs have also been identified as surface-water appropriation exclusion areas. One is located in Township 10N where the area within 1 mile (1.6 km) of the point of diversion or spring location is excluded and a possible regional spring located at 5-70E-11daa where the exclusion area has been extended to within a 3-mile (5-km) radius of the spring. One Air Force appropriation application point of diversion lies in an area excluded as

state land. This is application number 55022-2 at (C-29-19) 32dd.

4.8.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are three viable MX water-supply alternatives for Hamlin Valley. Each of the alternatives is discussed below in order of priority.

4.8.4.1 Alternative I

The first alternative MX water-supply system in Hamlin Valley consists of the use of the existing Air Force test well at 8N-69E-35da (number 41720), the construction of one MX water-supply well at the pending point of diversion at 9N-69E-15aa (number 41721), and the construction of two MX water-supply wells at locations that are not presently Air Force water-appropriation application points of diversion.

The primary advantage of this approach is the good distribution of MX water-supply wells that would be provided. The primary disadvantage is that the two points of diversion which occur in Utah (numbers 55022-2 and 55022-1) would require amendment.

There is no LSC scheduled for Hamlin Valley. The MX water demand for the construction of DTN and clusters ranges from 110 to 2620 acre-ft/yr (0.14 to 3.23 hm^2/yr) with the peak-year demand occurring in 1984. The existing Air Force test well

located at 8N-69E-35da (number 41720) is capable of supplying only 177 acre-ft/yr (0.22 hm^3/yr) and is located in a secondary water-supply well development area. Although this well has a yield of only 110 gpm (7 l/s), higher well yield potential is estimated for primary areas. If it is assumed that the average yield of additional MX water-supply wells is 510 gpm (32.7 l/s), one additional well will be required in 1983 and two more wells will be required to meet the peak-year demand of 1624 gpm (102 l/s) in 1984. MX water requirements decrease after 1984, and it will be possible to meet these requirements with either one or two wells or with a reduced pumping rate from all four wells.

4.8.4.2 Alternative II

The second alternative MX water-supply system in Hamlin Valley consists of the use of the existing Air Force valley-fill aquifer test well and the construction of two wells tapping the regional carbonate aquifer. The carbonate aquifer has a high yield potential in the valley (Section 4.8.1).

The primary advantage of this approach is that only two more wells would be constructed rather than the three additional wells in Alternative I. The primary disadvantages are that high well yields are not guaranteed from carbonate aquifer wells, and development of the carbonate aquifer would be more costly than development of the valley-fill aquifer as in Alternative I.

4.8.4.3 Alternative III

The third alternative MX water-supply system in Hamlin Valley consists of the use of the existing Air Force valley-fill

aquifer test well, the construction of one additional well in the Nevada portion of the valley, and the lease of existing surface-water or ground-water rights to augment the water-supply wells during the peak-year demand.

The primary advantage of this approach is that only one additional MX water-supply well would be required rather than the three additional wells in Alternative I. The primary disadvantages are that it would be necessary to purchase about 1650 acre-feet (2.03 hm^3) of water in 1984 and about 50 acre-feet (0.06 hm^3) in 1986, and it will be necessary to install water-distribution systems to transport the purchased water to central distribution points closer to MX construction activities.

4.8.4.4 General Well Characteristics

Well yields are variable in Hamlin Valley ranging from a few gallons per minute for some flowing wells in the northern part of the valley to reported yields of over 1000 gpm (63 l/s) for some large irrigation wells. With proper consideration of hydrologic and geologic factors, the expected yield for a properly designed well in Hamlin Valley is approximately 500 gpm (32 l/s). The Air Force test well is only capable of producing 110 gpm (7 l/s) but is located in a secondary area and is not considered to be representative of well yields that can be expected within primary areas. Over most of the valley, the depth to ground water ranges from 50 to 150 feet (15 to 46 m) below land surface. It is, therefore, recommended that additional MX

water-supply wells be drilled to depths not in excess of 500 feet (52 m).

Information on the depths required for wells tapping the regional carbonate aquifer is sparse in Hamlin Valley. A well less than 2000 feet (610 m) deep would probably be required.

4.8.5 Additional Investigations

Suggested sites for additional drilling and testing prior to operational development of the water-supply system are identified in Drawing 4-8 and are ranked in Table 4-19. The Air Force test well located in west-central Hamlin Valley at 8N-69E-35da (number 41720) has been tested and the data evaluated to provide information concerning the valley-fill aquifer in this part of the valley. Two additional drilling and testing sites have been identified in Hamlin Valley. The first priority site is located in the southern part of central Hamlin Valley at 7N-70E-26ac in a primary water-supply area as delineated on Drawing 4-8. It is not an existing point of diversion site, and is approximately 7.5 miles (12 km) southeast of the existing Air Force test well. One existing well is located about 3 miles (5 km) south of the site. The proposed site is well positioned with respect to the clusters and is close to the proposed DTN. There are no points of diversion in primary areas in this portion of the valley.

The second priority site, proposed Air Force point of diversion application number 41721 (9N-69E-15aa), is located in northwest Hamlin Valley in a primary water-supply area. No aquifer data

CRITERIA	POINTS OF DIVERSION						
		55022-1 31S-16W-33dd		41719 6N-70E-13dd		41720 + 8N-69E-35da	
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	4	20	4	20	1	5
Proximity to Const Camp or Plant	6	0	0	0	0	0	0
Proximity to DTN or Cluster	4	1	4	5	20	6	24
Sparse Data Area	10	10	100	10	100	0	0
Final Weighted Score			124		140		29

* Recommended additional drilling site(s) at points of diversion
\+ Existing Air Force test and observation wells

Point of diversion number 55022-1 was not considered due to its location in an excluded water supply area

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ADDITIONAL DRILLING/TESTING
SITE MATRIX
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CRITERIA	POINTS OF DIVERSION						
	41721 9N-69E-15aa						
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	5	25				
Proximity to Const. Camp or Plant	5	0	0				
Proximity to OTH of Cluster	4	5	20				
Sparse Data Area	10	10	100				
Final Weighted Score			145 *				

* Recommended additional drilling site(s) at points of diversion

An additional drilling and testing site has been selected at [illegible] in a [illegible] area where no points of diversion suitable for investigation exist. This site is located in a sparse data area.

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TABLE 4-19

exist within 5 miles (8 km) of the site which is situated on a broad expanse of alluviul fans. The existing Air Force well is located 10 miles (16 km) to the south in lacustrine deposits and was tested at 110 gpm (7 l/s) sustained rate with 83 feet (25 m) of drawdown. A well at the proposed site would provide the data needed to determine aquifer performance within the primary water-supply area. A distribution of clusters in the area and the site's location along the DTN enhance the potential for an MX water supply at this location.

4.9 LAKE VALLEY

4.9.1 Hydrologic Summary

Lake Valley, in Lincoln and White Pine counties, Nevada, is a north-south trending basin encompassing 975 mi^2 (2525 mi^2), of which 340 mi^2 (881 km^2) are suitable for MX deployment (Table 4-20). The valley is considered by the Nevada State Engineer to be two separate hydrographic basin of approximately equal area, Lake Valley in the north and Patterson Valley in the south. The two areas are separated by a low alluvial divide. Lake Valley is topographically closed, and Patterson is topographically open and drains southward into Meadow Valley Wash.

The combined Lake-Patterson Valley perennial yield is estimated at 17,000 acre-ft/yr (20.91 hm^3/yr) (State of Nevada, 1971). Ground-water certificates, proofs and permits total 25,333 acre-ft/yr (31.23 hm^3/yr) (Woodburn and others, 1981). Pending applications total 26,484 acre-ft/yr (32.65 m^3/yr) (DRI, 1980). On the basis of the valleys stated and shown in Table 4-20, ground-water appropriations in the Lake Valley system exceed availability. However, the relationship of perennial yield and water appropriations in the separate units of the system, Lake and Patterson, are quite disproportionate as shown below.

	PERENNIAL YIELD acre-ft/yr	APPLICATIONS acre-ft/yr	CERTIFICATES PROOFS/ PERMITS acre-ft/yr	AVAILABILITY acre-ft/yr
Lake Valley	12,000	18,012	24,174	-12,174
Patterson Valley	5,000	8,472	1,159	+3,841

Valley Area	Valley Length	Avg Valley Width	Suitable Area	Avg. Valley Floor Elevation
975 sq mi	71 mi	14 mi	340 sq mi	5600-6000 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	10-125 ft	5550-5950 ft	7000 sq ft/day	–

Perennial Yield	Ground-Water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
17,000	19,000	0	9000	8500	–

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds * Standards	Suitable for Construction	Exceeds ** Standards
3	3	0	3	0

WATER USE AND APPROPRIATIONS

Source	Current Use	Applications	Certificates, Proofs, Permits	Availability (1)
Ground Water	14,166	25,484	25,333	2834/-8333
Surface water	4583	2828	914	–

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction		554	2352	1489	1916	336	0	0	0
Operation									

(1) Perennial Yield - Current Use / Perennial Yield - Certificated Use
* State and Federal drinking water standards.
** Portland Cement Association recommendations (1968)

Note: All units are in acre-feet per year unless otherwise noted. Numbers are for Lake Valley and Patterson Valley hydrographic basins combined.

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HYDROLOGIC SUMMARY
LAKE VALLEY, NEVADA

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TABLE 4-20

The Nevada State Engineer has designated the northern Lake Valley portion as a critical ground-water basin because of over use; however, the southern area, Patterson Valley, is undesignated and perennial yield exceeds approved appropriations by 3841 acre-ft/yr (4.74 hm^3/ yr).

The valley-fill aquifer in overall Lake Valley is considered a good source of supply with average transmissivities of 7000 ft^2/day (650 m^2/day) reported. The valley-fill aquifer has an estimated 3.6 million acre-feet (4440 hm^3) of water stored in the upper 100 feet (31 m) of saturated sediments (State of Nevada, 1971).

The potential for carbonate aquifer development in overall Lake Valley is low. Geologic conditions are generally unfavorable and land-use restrictions exist on the limited favorable drilling areas. Surface water sources are limited. Streams on the valley floor are ephemeral and not a reliable source of supply. All spring discharges are appropriated and would only be available for use through lease or purchase.

Water-quality data are available from one well and one spring located in the north and one well in the southern portion of the valley. Water from these sites meets the State of Nevada primary and secondary standards for drinking water and are suitable for construction purposes.

4.9.2 Water-Supply Sources

Lake Valley includes Lake Valley hydrographic basin which is over appropriated and Patterson Valley hydrographic basin which

has unappropriated ground water available (Woodburn and others, 1981). The matrix evaluation of water-supply sources presented in Table 4-21 is for the overall Lake Valley area which includes the two hydrographic basins.

The lease or purchase of existing water rights is the preferred source of water supply for MX construction in overall Lake Valley. Although the valley is over appropriated, there is an abundance of existing water rights that could be leased or purchased. The 25,333 acre-ft/yr (31.23 hm^3/yr) of existing ground-water rights are high compared to the peak MX construction water requirements of 2352 acre-feet (2.90 hm^3) in 1984. Lease or purchase of existing ground-water rights, although about two times more costly than development of the valley-fill or carbonate aquifers, would have the least environmental impact potential of the four potential sources of water supply if current water use were diverted for MX use and additional ground-water withdrawals were minimized.

Development of the valley-fill aquifer is ranked second to the lease/purchase option as a source of water supply because the perennial yield of the valley is over appropriated, and, thereby, it received a low legal water-availability ranking. Additional appropriation of ground water beyond the perennial yield in Lake Valley can be granted by the State Engineer. His decision need not be based solely on the perennial yield of the basin, but can also consider the quantity of ground water in storage in the upper 100 feet (30 m) of saturated valley fill,

Criteria	Weight	Valley-Fill Aquifer Score	Valley-Fill Aquifer Wt Score	Carbonate Aquifer Score	Carbonate Aquifer Wt. Score	Lease/ Purchase Score	Lease/ Purchase Wt. Score	Importation Score	Importation Wt. Score
Legal Water Availability	0	0	0	0	0	10	100	8	80
Impacts on Man or Environment	10	6	60	6	60	7	70	6	60
Development Potential (Physical Availability)	10	10	100	1	10	10	100	7	70
Cost	4	10	40	2	8	6	24	0	0
Timeliness	6	10	60	2	12	10	60	2	12
Water Quality	2	10	20	10	20	10	20	10	20
Final Weighted Score			[illegible]		110		370*		242

* Recommended source of water supply
** First alternative source of water supply

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WATER-SUPPLY SOURCE MATRIX
LAKE VALLEY, UTAH

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TABLE 4-21

the distribution and type of current water use, the quantity of water requested, and the duration of the intended use. Thus, additional development of the valley-fill aquifer is a viable alternative. It is believed to have only slightly more impact potential than the lease/purchase option, has a high development potential, is the least costly of the four alternatives, is very timely, and has no water-quality limitations. The aquifer is generally shallow and is estimated to yield large quantities of water to wells based on current water-use activities in the valley and drillers' specific capacity tests. It should be noted that in the Patterson Valley portion of the basin, development of the valley-fill aquifer may be the preferred water-supply source because sufficient quantities of unappropriated ground-water exist.

Importation of water ranked third because of the high projected cost (at least 23 times the cost of the valley-fill alternative) of temporary pipelines and pumping stations and the time (a minimum of six times longer than the valley-fill alternative) required to install such a system from Spring Valley, the source valley.

Development of the carbonate aquifer ranked the lowest of the four water-supply sources because of estimated low development potential, higher cost (just over five times the cost of the valley-fill alterntive), the longer length of time required to develop (four times valley-fill alternative), and its projected low legal availability. The only area of significant potential

for development of the carbonate aquifer is Dutch John Mountain located to the west of the northern portion of the valley.

4.9.3 Suitable Areas for Water-Supply Well Locations

Although current ground-water withdrawals in Lake Valley exceed the perennial yield, additional water rights may be granted by the State Engineer's office under certain circumstances. If no permits are granted, water rights will have to be leased or purchased. In either case, consideration of primary and secondary areas should help determine optimum use of available area. Shown on Drawing 4-9 are the primary and secondary areas for the construction of MX water-supply wells in Lake Valley, Nevada.

Based on the selection criteria used, about 100 mi^2 (259 km^2) of primary area has been delineated. Most of this area is confined to the southern and central parts of the valley due to extensive deposits of lacustrine sediments in the north and north-central parts of the valley. However, three small primary areas have been delineated along the alluvial fans in north Lake Valley and comprises a total area of about 6 mi^2 (16 km^2). The remaining primary area, located in south and central Lake Valley, extends from Township 6N to Township 10N and comprises an area of about 94 mi^2 (238 km^2). Three of the five Air Force water-appropriation application points of diversion are located in primary water-supply well development areas at 4N-67E-20bd (number 41811), 3N-67E-19ab (number 41812), and 2N-67E-5ad (number 41793).

Due to the extensive deposition of fine-grained sediments in the northern and north-central parts of the valley, a large area is classified as secondary. This area extends from Township 6N to Township 10N and is about 75 mi^2 (195 km^2). Based on the interpretation of available geophysical and water-level data, several secondary areas have been delineated along the valley flanks where shallow bedrock and limited thicknesses of valley-fill sediments occur. Most of this area occurs in Township 2N and 3N along the eastern side of the valley. Two of the five Air Force water-appropriation application points of diversion are located in secondary areas for water-supply well development at 7N-66E-27ad (number 41813) and 9N-66E-15bb (number 41814).

A number of small fee-land exclusion areas occur throughout Lake Valley, and a large area of cultural exclusions occurs in the southern part of the valley around the community of Pioche, Nevada. Also, an excess of 100 existing wells or ground-water appropriation exclusion areas (a 1-mile [1.6-km] radius from the point of diversion or well location) are located throughout the valley, and 22 undesignated or surface water appropriation exclusion areas (a 1-mile [1.6-km] radius from the point of diversion or spring location) occur. Geyser Spring (9N-65E-4c), located along the rock valley-fill contact in the northwest part of the valley, has been identified by Ertec as a possible regional spring. All area within a 3-mile (5-km) radius of the spring has been excluded.

4.9.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are two viable MX water-supply alternatives for Lake Valley. The significant features of these alternatives are described below. The alternatives are listed in order of priority.

4.9.4.1 Alternative I

Existing ground-water rights and pending appropriation applications in Lake Valley hydrographic basin (northern Lake Valley) exceed the perennial yield. Consequently, the valley has been designated by the Nevada State Engineer's office as a critical ground-water basin. Therefore, the most viable water-supply source will be lease or purchase of water rights from existing owners. There are a number of high volume agricultural wells throughout the valley which would be suitable for use as MX water-supply wells.

Assuming an average well yield of 750 gpm (47 l/s), one well will be required in 1983 and two wells will be required to meet the peak demand of 2352 acre-feet (2.89 hm^3) in 1984. After 1984, MX water requirements can be met with only one well. It may be preferable, however, to lease or purchase water from a number of wells throughout the valley. Locating these wells near the LSC, DTN, and cluster construction areas will result in a more efficient distribution of water supplies.

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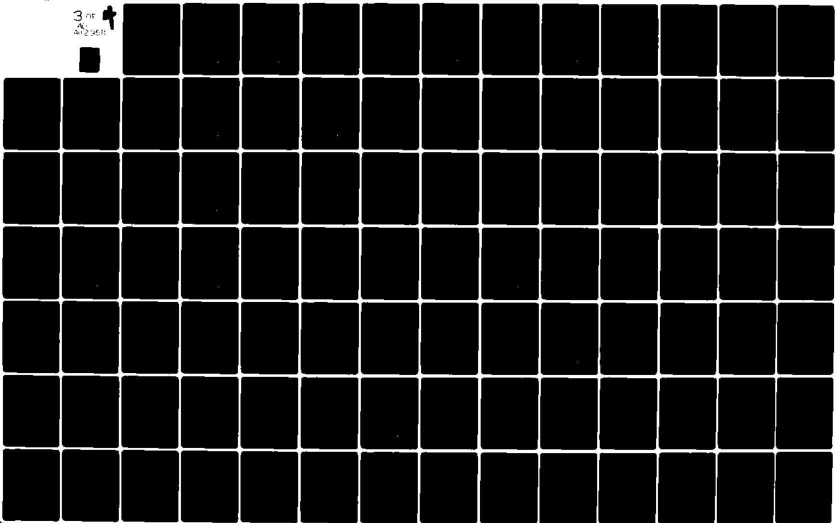

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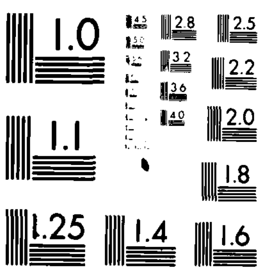

MICROCOPY RESOLUTION TEST CHART
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4.9.4.2 Alternative II

This alternative involves development of the valley-fill aquifer and use of the Air Force's pending points of diversion. Ground water is available for appropriation in the Patterson hydrographic basin as existing appropriations do not exceed perennial yield. Ground water available for appropriation exceeds the peak-year MX requirement of 2352 acre-ft/yr (2.89 hm^3/yr) in 1984. Also, additional appropriation of ground water in the Lake hydrographic basin is possible since the State Engineer does not base his decision solely on perennial yield.

MX water-supply wells should be located at pending Air Force points of diversion. Several of these sites (shown in Drawing 4-9) are near the proposed LSC or DTN and cluster construction areas. Again assuming a well yield of 750 gpm (47 l/s), one well will be required in 1983 and two wells will be required in 1984. During the period 1985 through 1987, both wells should be pumped at reduced rates.

4.9.5 Additional Investigations

A suggested site for additional drilling and testing is identified in Drawing 4-9. Potential sites are ranked in Table 4-22.

In southern and central Lake Valley, stock wells provide insufficient data concerning aquifer performance. A pending Air Force point of diversion, number 41811 (7N-67E-20bd), located in southern Lake Valley in a primary area, is recommended for drilling and testing. The site has a fair distribution of

CRITERIA	POINTS OF DIVERSION						
		41793 2N-67E-5ad		41812 3N-67E-19ab		41811 4N-67E-20bd	
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	9	45	9	45	9	45
Proximity to Const. Camp or Plant	6	0	0	0	0	0	0
Proximity to DTN or Cluster	4	0	0	2	8	6	24
Sparse Data Area	10	5	50	4	40	5	50
Final Weighted Score			95		93		119 *

* Recommended additional drilling site(s) at points of diversion

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ADDITIONAL DRILLING/TESTING
SITE MATRIX
LAKE VALLEY, NEVADA
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TABLE 4-22

CRITERIA	POINTS OF DIVERSION						
		41814 9N-66E-15bb		41813 7N-66E-27ad			
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	8	40	10	50		
Proximity to Const. Camp or Plant	6	0	0	5	30		
Proximity to DTN or Cluster	4	3	12	5	20		
Sparse Data Area	10	4	40	3	30		
Final Weighted Score			92		130		

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ADDITIONAL DRILLING/TESTING
SITE MATRIX
LAKE VALLEY, NEVADA
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TABLE 4-22

clusters within a 5-mile (8-km) radius and could be utilized as an MX water-supply well for southern Lake Valley.

Aquifer data in northern Lake Valley are sufficient to characterize the valley-fill aquifer. Due to the sufficient data available, two proposed Air Force points of diversion, 41813 (7N-66E-27ad) and 41814 (9N-66E-15bb), are not recommended as additional drilling locations even though they scored higher than pending point of diversion 41811.

4.10 MULESHOE VALLEY

4.10.1 Hydrologic Summary

Muleshoe Valley is a topographically open basin in Lincoln County, Nevada. Of the approximately 200 mi^2 (518 km^2) of valley area, 55 mi^2 (143 km^2) are suitable for MX deployment (Table 4-23).

Muleshoe Valley is hydrologically connected with Dry Lake Valley, and the two valleys are considered as a single hydrographic unit by the Nevada State Engineer. Ground water in Muleshoe-Dry Lake Valley is presently undeveloped, however, there are 20 acre-feet/yr (0.02 hm^3/yr) of pending applications and 19 acre-ft/yr (0.02 hm^3/yr) of certificated or permitted rights (Woodburn and others, 1981) for ground-water withdrawal in the valleys. Surface water in Muleshoe Valley is completely appropriated.

Perennial yield is estimated at 3000 acre-ft/yr (3.70 hm^3/yr) for the Muleshoe-Dry Lake basin (State of Nevada, 1971). The combined peak-year MX water requirements in the two valleys, 968 acre-ft/yr (1.20 hm^3/yr) for Muleshoe and 3373 acre-ft/yr (4.20 hm^3/yr) for Dry Lake, in 1984 would exceed the Muleshoe-Dry Lake basin perennial yield by 1341 acre-feet (1.65 hm^3). However, the combined total ground water in storage within the upper 100 feet of saturated sediment in Dry Lake and Delamar valleys is estimated at 2.8 million acre-feet (3452.4 hm^3) (State of Nevada, 1971), which is very large compared to the estimated overdraft. This suggests that the peak water demand

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg. Valley Width	Suitable Area	Avg. Valley Floor Elevation
200 sq mi	21 mi	10 mi	55 sq mi	5700 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	300 ft	5000-5600 ft	–	–

Perennial Yield	Ground-Water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
3000	2100	0	2100	0	–

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds * Standards	Suitable for Construction	Exceeds ** Standards
3	3	0	3	0

WATER USE AND APPROPRIATIONS (1)

Source	Current Use	Applications	Certificates/ Proofs/Permits	Availability (2)
Ground Water	0	20	19	3000/2981
Surface Water	21	2596	–	–

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction Operation	4	251	268	292	341	193	0	0	0

(1) Muleshoe and Dry Lake valleys combined
(2) Perennial Yield - Current Use / Perennial Yield - Certificated Use
* State and federal drinking water standards.
** Portland Cement Association recommendations (1968)

Note: All units are in acre-feet per year unless otherwise noted

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HYDROLOGIC SUMMARY
MULESHOE VALLEY, NEVADA

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TABLE 4-23

could be easily sustained if temporary overdraft is allowed by the Nevada State Engineer.

Little is known about the valley-fill aquifer in Muleshoe Valley. Test borings conducted by Ertec indicate that the valley-fill is composed of gravel, sand, silt, and clay mixtures. Aquifer testing is presently being performed by Ertec at an Air Force test well located at 4N/64E-7dc. Preliminary results compiled during testing suggest a transmissivity of less than 500 ft^2/day (46 m^2/day). Results from ongoing numerical modeling indicate higher transmissivities may be possible, ranging from 800 ft^2/day (74 m^2/day) near the Muleshoe/Dry Lake boundary to 6400 ft^2/day (596 m^2/day) in the center of the valley.

Water-chemistry data for the valley-fill aquifer in Muelshoe Valley are not available as of this date. Ground-water down-gradient in Dry Lake Valley is known to be of acceptable quality for drinking and construction. Therefore, it is expected that the ground water in most of Muleshoe Valley will be suitable for drinking and construction purposes. Water-chemistry data are available for three small springs around the margins of the valley, and these sites meet state and federal standards for drinking water.

4.10.2 Water-Supply Sources

Development of the valley-fill aquifer through the acquisition of new permits is the preferred source of water supply in Muleshoe Valley (Table 4-24). Development of the valley-fill

Criteria	Weight	Valley-Fill Aquifer Score	Valley-Fill Aquifer Wt Score	Carbonate Aquifer Score	Carbonate Aquifer Wt Score	Lease/ Purchase Score	Lease/ Purchase Wt. Score	Importation Score	Importation Wt. Score
Legal Water Availability	10	7[1]	70	7	70	0	0	8	80
Impacts on Man or Environment	10	9	90	9	90	7	70	6	60
Development Potential (Physical Availability)	10	4	40	9	90	5	50	10	100
Cost	4	10	40	3	12	3	12	1	4
Timeliness	6	10	60	2	12	7	42	2	12
Water Quality	2	10	20	10	20	10	20	10	20
Final Weighted Score			320*		294+		197		276

1 Includes Dry Lake (Muleshoe area)
* Recommended source of water supply
\+ First alternate source of water supply

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WATER-SUPPLY SOURCE MATRIX
MULESHOE VALLEY, NEVADA

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TABLE 4-24

aquifer is estimated to be the least costly and the most timely of the four water-supply options. The legal availability of water was ranked second to importation for the following reasons. The state estimated perennial yield of the hydrographic basin can supply only about 70 percent of the peak-year MX water needs. However, there is no observed ground-water use in Muleshoe Valley, and the State Engineer does not limit his decisions on the approval of ground-water applications solely to a comparison of approved water rights versus the perennial yield of the basin. Quantity, distribution, and type of present ground-water use is considered as well as the quantity of water in storage in the saturated valley-fill sediments.

Development of the carbonate aquifer in Muleshoe Valley ranked second because of the greater cost (about three times that of the valley-fill option) and time (four times the valley-fill option) to develop this source versus the valley-fill aquifer. The carbonate aquifer does, however, have a high well yield potential as indicated by the Air Force carbonate aquifer test (3N-63E-27cc) conducted about 5 miles (8 km) south of the margin of the valley in Dry Lake Valley. Conditions favorable for high-yield potential similar to those at the test site exist in Muleshoe Valley.

Importation of water is ranked third among the four options because it is many more times as expensive as development of the valley-fill aquifer and would take significant time to develop. Importation of water ranked high in legal and physical development because of the large ground-water basin and the high yield

potential of the valley-fill aquifer from which the water could be imported (Spring Valley).

Lease or purchase of existing water rights should not be considered at this time since there are only 19 acre-ft/yr (0.02 hm^3/yr) (Woodburn and others, 1981) and only 21 acre-ft/yr (0.03 hm^3/yr) of surface-water use (DRI, 1980). These total less than one percent of the combined MX peak-year water requirement for Muleshoe and Dry Lake valleys in 1984.

4.10.3 Suitable Areas for Water-Supply Well Locations

The primary areas for the construction of MX water-supply wells in Muleshoe Valley, Nevada, are shown in Drawing 4-10.

Based upon the available data and the selection criteria, all the area of the valley floor greater than 1 mile (1.6 km) basinward of the rock/valley-fill contact is classified as primary except for one small cultural exclusion and a 0.25-mile (0.40-km) radius exclusion area around a reservoir in the northern part of the valley. The distribution of primary areas is such that there is sufficient area for the development of an adequate ground-water supply for the construction and operation of the MX missile system. Two of the three Air Force ground-water-appropriation application points of diversion lie within primary areas for water-supply well development. These are application numbers 41734 (4N-64E-7dc) and 41733 (5N-65E-6ca).

No secondary areas were identified in Muleshoe Valley.

A small cultural exclusion at 6N-64E, a small exclusion area for a reservoir, and the area within 1 mile (1.6 km) of the rock/valley-fill boundary are the only exclusionary areas in Muleshoe Valley. One of the three Air Force applications for ground-water appropriations, number 41732 at 6N-65E-6bc lies in the excluded area (shallow rock) for water-supply well development.

4.10.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are two viable MX water-supply system alternatives for Muleshoe Valley. Each of these alternatives are discussed below in order of their priority.

4.10.4.1 Alternative I

This alternative consists of the use of the existing Air Force test well located at 4N-64E-7dc (number 41734) and the construction of three new water-supply wells tapping the valley-fill aquifer.

The primary advantage of this alternative is that it could be developed at low cost and the wells could be constructed quickly compared to other alternatives. The primary disadvantage is that only one of the undeveloped Air Force application points of diversions lie within area suitable for water supply-well development, and amendment of some of the applications would be necessary. This could delay the amended point of diversion's availability for well construction.

There is no LSC scheduled for Muleshoe. The water requirement for the construction of the DTN and clusters ranges from 251 acre-ft/yr (0.31 hm^3/yr) to 968 acre-ft/yr (1.20 hm^3/yr) with the peak-year demand occurring in 1984.

The existing Air Force test well may only be capable of supplying 81 acre-ft/yr (0.10 hm^3/yr) of the peak MX requirement of 968 acre-ft/yr (1.20 hm^3/yr). However, the preliminary results of valley-fill aquifer testing by Ertec in Muleshoe Valley may not be indicative of the overall valley-fill aquifer characteristics as indicated by the numerical modeling results for the valley (Section 4.10.1). It is assumed that a well yield of 250 gpm (56 l/s) may be possible in other areas of the valley. This rate of withdrawal is equivalent to 403 acre-ft/yr (0.50 hm^3/yr) if withdrawn continuously. This would mean that, in addition to the existing Air Force test well, one well would be required in 1983, three wells in 1984, and one well from 1985 through 1987 when MX construction would be completed in this valley.

4.10.4.2 Alternative II

This alternative consists of the use of the existing Air Force test well located at 4N-64E-7dc (number 41734) and the construction of one carbonate aquifer well. The primary advantage of this approach is that the water supply could be developed relatively quickly compared to importation of water to Muleshoe Valley and with fewer wells than would be required for valley-fill aquifer development. The primary disadvantages are

the higher cost relative to valley-fill aquifer development, and amendments to Air Force applications would be necessary.

The carbonate aquifer in Muleshoe Valley is estimated by Ertec to have a high development potential because of the presence of thick hydrostratigraphic units favorable for high well yields, the lack of thick aquitards, the presence of high density faulting, the occurrence of the valley in a regional flow regime, and minimal land-use restrictions on favorable drilling areas. It may be possible, based on the above favorable conditions, to develop a yield of 900 gpm (16 l/s) from a well tapping the carbonate aquifer in this valley. This quantity would be equivalent to 1449 acre-ft/yr (1.78 hm^3/yr) if pumped continuously, which is more than the 968 acre-ft/yr (1.20 hm^3/yr) required for MX construction in 1984.

4.10.4.3 General Well Characteristics

The only recorded well yield in Muleshoe Valley is for the Air Force test well located at 4N-64E-7dc. This well was constructed with a 16-inch (41-cm) borehole and 10-inch (25-cm) ID casing to a total depth of 1215 feet (370 m) but is capable of a sustained yield of only 50 gpm (3 l/s). No wells have been drilled into the carbonate aquifer in Muleshoe Valley, but, as discussed in Alternative II, a high well yield potential is estimated. Carbonate aquifer wells should be constructed to the specifications described in Section 3.3.1.

4.10.5 Additional Investigations

The remaining Air Force application point of diversion is the only site for future drilling and testing prior to operational development of the water-supply system (Drawing 4-10). The Air Force test well located in southern Muleshoe Valley at 4N-64E-7dc is presently being tested and the data will be evaluated to provide information concerning the valley-fill aquifer in the southern part of the valley. Preliminary results indicate a sustained yield of 50 gpm (3 l/s) with a drawdown of approximately 200 feet (61 m).

A pending Air Force point of diversion, number 41733, is located in the east-central part of the valley at 5N-65E-6ca in the primary water-supply area delineated in Drawing 4-10. No aquifer data exist in this part of the valley and a well at the proposed site would provide the data needed to characterize the production potential of the broad alluvial fans which extend along the eastern side of the valley and determine whether yields greater than 50 gpm (3 l/s) can be achieved from a well tapping the valley-fill aquifer. The site is located 2 miles (3 km) from the DTN, with a good distribution of shelters in the area. This would allow the site to be utilized as an MX water supply if a sufficient quantity of water could be obtained from the valley-fill aquifer.

The Air Force point of diversion (number 41732) was not considered for additional investigation because it lies in an excluded (shallow rock) water-supply area.

4.11 PAHROC VALLEY

4.11.1 Hydrologic Summary

Pahroc Valley is situated in central Lincoln County, Nevada, and is considered by the Nevada State Engineer (1971) as part of the Pahranagat hydrographic basin. It is topographically connected at its northeastern margin to Dry Lake Valley and may be hydrologically interconnected with White River, Pahranagat, Coyote Spring, and Kane Springs valleys. These hydrologically interconnected valleys form the lower segment of the White River ground-water flow system, a regional carbonate system. Pahroc Valley encompasses an area of 140 mi^2 (363 km^2) of which 85 mi^2 (220 km^2) are considered suitable for MX deployment (Table 4-25).

Ground water is presently undeveloped in the Pahroc Valley portion of the hydrographic basin where there are no permitted ground-water rights. The perennial yield of the Pahranagat hydrographic basin is reported as 25,000 acre-ft/yr (30.82 hm^3/yr) (State of Nevada, 1971). There is 1320 acre-feet (1.62 hm^3) of unappropriated perennial yield available in Pahranagat hydrographic basin (Woodburn and others, 1981). Withdrawal of the peak-year MX water requirement of 341 acre-feet (0.42 hm^3) in 1984 in Pahroc Valley is well within the 1320 acre-ft/yr (16.27 hm^3/yr) of perennial yield available in the overall Pahranagat hydrographic basin. The perennial yield of the Pahroc valley segment is estimated by Ertec to be approximately 400 acre-feet (0.5 hm^3) which is also greater than the peak-year MX requirements.

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg. Valley Width	Suitable Area	Avg. Valley Floor Elevation
140 sq mi	14 mi	10 mi	95 sq mi	4300-4600 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	590-700 ft (1)	3600-3800 ft (1)	— (1)	— (1)

Perennial Yield	Ground-Water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET (1)	Surface Discharge
25,000	300-400	0	—	0	minor

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds * Standards	Suitable for Construction	Exceeds ** Standards
0	—	—	—	—

WATER USE AND APPROPRIATIONS

Source	Current Use (1)	Applications	Certificated Permits Rights	Availability (2)
Ground Water	0	22,370	22,260	1221
Surface Water	0	—	—	—

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction	70	126	241	129	117	0	0	0	0
Operation									

1. Pahroc Valley only
2. Perennial Yield - Current Use; Perennial Yield - Certificated Use
3. State and Federal drinking water standards
4. Portland Cement Association recommendations, [illegible]

Note: All units are in acre-feet per year unless otherwise noted.

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HYDROLOGIC SUMMARY
PAHROC VALLEY, NEVADA

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TABLE 4-25

Drillers' logs provide the only information available for the assessment of the valley-fill aquifer. These logs indicate a valley-fill thickness in excess of 300 feet (91 m) and composed of fine-grained sand and clay. Some of the well logs indicate the occurrence of rhyolitic volcanic rock which may have potential as an aquifer. The hydraulic properties of the valley-fill aquifer have not been determined. Surface water in Pahroc Valley is derived from seasonal springs, one of which has been appropriated.

Chemistry data are not available to assess limitations of the ground-water resource for drinking or construction water purposes.

4.11.2 Water-Supply Sources

The development of the valley-fill aquifer through acquisition of new permits is the preferred MX water-supply source in Pahroc Valley (Table 4-26), although it has an equilvalent ranking to the lease/purchase option for water supply. Development of the valley-fill aquifer is the least costly, and is very timely.

The development potential of the valley-fill aquifer in Pahroc Valley is, however, considered low because of the great depths to water and possible limited saturated thickness of the valley-fill sediments. However, the quantity of water required for peak MX construction is quite small (341 acre-feet [0.42 hm^3]), and the yield of wells tapping the valley-fill aquifer could be small and still be sufficient to meet this requirement. The

Criteria	Weight	Valley-Fill Aquifer Score	Valley-Fill Aquifer Wt Score	Carbonate Aquifer Score	Carbonate Aquifer Wt Score	Lease/Purchase Score	Lease/Purchase Wt. Score	Importation Score	Importation Wt. Score
Legal Water Availability	10	10	100	10	100	10	100	8	80
Impacts on Man and Environment	10	8	80	8	80	8	80	6	60
Development Potential (Physical Availability)	10	3	30	7	70	3	30	10	100
Cost	4	10	40	5	20	10	40	8	32
Timeliness	6	10	60	2	12	10	60	2	12
Water Quality	2	10	20	10	20	10	20	10	20
Total Weighted Score			330*		302		330+		304

* Recommended source of water supply
\+ First alternative source of water supply

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WATER-SUPPLY SOURCE MATRIX PAHROC VALLEY, NEVADA

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TABLE 4-26

development potential of the valley-fill aquifer should be verified through exploratory drilling and testing prior to well field design.

Lease or purchase of existing water rights is ranked second because of the large quantity of approved ground-water rights in Pahranagat hydrographic basin. The viability of the lease/purchase option depends on the viability of valley-fill aquifer development in Pahroc Valley. There is no present ground-water use or developed wells in Pahroc Valley and the surface-water resource is not of sufficient magnitude.

If the valley-fill aquifer in Pahroc Valley cannot supply the yields required for MX construction, importation of water would be the preferred water-supply source. Importation of water is presently ranked third, although it has essentially the same score as carbonate aquifer development. There is enough water available in neighboring Pahranagat Valley to supply MX needs in Pahroc Valley which is part of the same hydrographic basin. Because the ground water would be used in the same hydrographic basin, it technically is not being imported, although transportation from one geographic valley to the next occurs. Importation from Pahranagat Valley is given a lower legal availability ranking than the Pahroc valley-fill aquifer because the Nevada State Engineer may still prefer that ground water not be transferred from one valley to another. Importation of water is relatively untimely to develop (six times the valley-fill option) but is estimated to be only 1.2 times more costly than developing the valley-fill aquifer in Pahroc Valley.

Development of the carbonate aquifer ranks close to importation because it has a high legal availability and moderately high development potential. It is considered a less viable option than importation because it is the most costly (about two times the cost of the valley-fill alternative) of the four options and would essentially be no more timely.

4.11.3 Suitable Areas for Water-Supply Well Locations

The primary and secondary areas for the construction of MX water-supply wells in Pahroc Valley, Nevada, are shown in Drawing 4-4. Based on the selection criteria used, only a small area of about 5 mi^2 (12.9 km^2) have been delineated in Pahroc Valley as primary in the northern portion of the valley. There is one Air Force water-appropriation application point of diversion in a primary area for water-supply wells. This is located at 4S-62E-6ba (number 41693).

Greater than 85 percent of the available area for the location of MX water-supply wells has been classified as secondary. Due to deep ground-water levels and shallow depths to bedrock within these areas, as indicated by Air Force gravity surveys and hydrologic investigations, only limited thickness of saturated valley-fill sediments is anticipated. The potential yield of the underlying volcanic rock noted in driller's logs is presently unknown. There are two Air Force water-appropriation application points of diversion in secondary water-supply areas. These are located at 4S-61E-22bc (number 41695) and 4S-62E-8dc (number 41694).

Only two cultural fee-land exclusion areas occur in Pahroc Valley. There are no known regional or possible regional springs within Pahroc Valley. There is one Air Force water-appropriation application point of diversion located in an excluded area for water-supply wells. This is located at 4S-61E-25ca (number 41692) within 1 mile (1.6 km) of a certificated surface-water right for a spring.

4.11.4 Water-Supply System Alternatives

Based on the available hydrologic data and the matrix analyses conducted as part of this investigation, there are two MX water-supply system alternatives for Pahroc Valley. Each of the alternatives is discussed below in order of their priority.

4.11.4.1 Alternative I

The first alternative MX water-supply system consists of construction of an MX water-supply well at the pending point of diversion at 4S-62E-6ba (number 41693) in the primary area in the northern part of Pahroc Valley. If a well yield of 211 gpm (13 l/s) can be achieved from the well, no additional MX water-supply wells will be required.

There is no LSC scheduled for Pahroc Valley. The MX water demand for DTN and cluster construction ranges from only 70 to 341 acre-ft/yr (0.09 to 0.42 hm^3/yr) with the peak-year demand in 1984. The entire MX water requirement can be met with one well pumping from 43 to 211 gpm (3 to 13 l/s).

The primary advantage of this approach is that an adequate MX water supply could be developed with the construction of only

one water-supply well. The primary disadvantage is than MX construction activities in Pahroc Valley would depend on the operation of one well which could develop unforeseen problems with pumping equipment.

4.11.4.2 Alternative II

The second alternative MX water-supply system consists of the importation of water via pipeline from nearby Pahranagat Valley. A water source in Pahranagat Valley could be developed through the lease of water from existing water users or through the appropriation and development of the ground water available in the valley-fill aquifer.

Although it would not be necessary to pump a large amount of water from Pahranagat Valley to MX distribution points in Pahroc Valley, it would be more costly than development of the valley-fill aquifer. The pipeline would be at least 6 miles (10 km) long and pumping stations would be required to lift the water from the valley floor in Pahranagat Valley, elevation of 3840 feet (1170 m), to the pass between the two valleys where the elevation is 4050 feet (1234 m).

The major advantage is that no well drilling would be required if the water could be leased in Pahranagat Valley. The major disadvantages of this approach are the cost and time required to construct the pipeline.

4.11.4.3 General Well Characteristics

Due to the limited ground-water development in Pahroc Valley, there are little data concerning aquifer properties and well

yields. A well driller's report filed with the Nevada State Engineer's office indicates that a yield of 200 gpm (126 l/s) was obtained from a 1314-foot (4001 m) deep well at 4S-61E-28cac. This well, however, was completed in volcanic bedrock and a torch-cut perforated casing of 8 5/8-inch (22-cm) ID was used. Whether production was from valley fill or the volcanics was not indicated. This location is about 5 miles (8 km) southwest of the recommended water-supply well location at 4S-62E-6ba and is within an area excluded for water-supply well development for shallow rock reasons. Volcanic rock may not be penetrated by wells tapping the valley-fill aquifer in the primary area. If MX water-supply wells are constructed in the valley fill, it is recommended that larger casing be used and well screen installed rather than torch-cut perforated casing. A total well depth of 1300 feet (396 m) is recommended due to the depths to water in the valley which are believed to be in excess of 600 feet (183 m) below ground surface (Eakin, 196[illegible]).

4.11.5 Additional Investigations

Suggested possible sites for additional drilling and testing prior to operational development of the water-supply system are identified in Drawing 4-4 and are ranked in Table 4-27.

Three of the four pending Air Force points of diversion are located in suitable water-supply areas. The point of diversion at 4S-61E-25ca (number 41692) was not considered as an additional investigation site because it is located in an excluded area. Only one of the pending Air Force points of diversion is

CRITERIA	POINTS OF DIVERSION						
		41694 4S-62E-8dc		41695 4S-61E-22bc		41693 4S-62E-6ba	
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	1	5	3	15	2	10
Proximity to Const. Camp or Plant	6	0	0	0	0	0	0
Proximity to DTN or Cluster	4	5	20	5	20	6	24
Sparse Data Area	10	10	100	3	30	9	90
Final Weighted Score			125		65		124 *

* Recommended additional drilling site(s) at points of diversion

Point of diversion number 41692 was not considered due to its location in excluded water-supply area.

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ADDTIONAL DRILLING/TESTING
SITE MATRIX
PAHROC VALLEY, NEVADA

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TABLE 4-27

located in a primary water-supply area. This is the point of diversion at 4S-62E-6ba (number 41693) and it is recommended for investigation prior to operational development of the water-supply system. As discussed in Section 4.11.4.1, construction of a well at this site could be all the well construction that is required for the total water-supply system in Pahroc Valley if a sufficient well yield (211 gpm [13 l/s]) could be achieved.

The depth to water of this location is anticipated to be greater than 700 feet (213 m). Greater thickness of saturated valley-fill deposits are expected to be present in this primary area than at the two pending points of diversion located in secondary areas. This site (4S-62E-6ba) is also located with 3 miles (5 km) of the DTN route and has a good distribution of shelters around it.

4.12 PINE VALLEY

4.12.1 Hydrologic Summary

Pine Valley is a north-south trending, topographically closed basin in Millard, Beaver, and Iron counties, Utah. Of the 730 mi^2 (1890 km^2) of valley area, approximately 265 mi^2 (686 km^2) are suitable for MX deployment (Table 4-28). The perennial yield of the basin is estimated at 7000 acre-ft/yr (8.63 hm^3/yr) (Price, 1979) and storage within the upper 100 feet of saturated sediment is about 1.2 million acre-feet (1480 hm^3) (Price, 1979). Present ground-water use in Pine Valley is 18 acre-ft/yr (0.02 hm^3/yr), but there are 17,266 acre-ft/yr (21.30 hm^3/yr) of pending applications and permits for ground-water use (DRI, 1980). Nearly all of this quantity is believed to be in the application stage because, according to representatives of the State Engineer's office, the ground-water applications filed by the Pine Grove Associates Company for a potential molybdenum mine in southern Pine Valley in (C-28-18) has not yet been approved. These total 15,243 acre-ft/yr (18.79 hm^3/yr). Withdrawal of the peak-year MX water requirement of 2172 acre-feet (2.76 hm^3) is well below the unappropriated perennial yield available unless a significant portion of the 17,266 acre-ft/yr (21.30 hm^3/yr) of pending appropriations is approved and withdrawal starts prior to 1987, the last year MX withdrawals for construction are expected.

Ground water occurs both under confined and unconfined conditions in Pine Valley. Confined conditions occur locally in the valley-fill aquifer where impermeable volcanic rocks are

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg Valley Width	Suitable Area	Avg Valley Floor Elevation
730 sq mi	44 mi	17 mi	265 sq mi	5600 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-Fill	300-400 ft	4800-5400 ft	[illegible] sq ft/day	0.002

Perennial Yield	Ground-Water Recharge (pot)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
7000	21,000	0	14,000	5500	1590

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds (1) Standards	Suitable for Construction	Exceeds * Standards
20	19	1	20	0

WATER USE AND APPROPRIATIONS

Source	Current Use	Permits, Applications	Certificated	Availability (2)
Ground Water	13	17,226	[illegible]	[illegible]
Surface Water	29	2416	[illegible]	[illegible]

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction Operation		250	2172	1474	1774	772	0	0	0

(1) Surface water sample from Indian Creek (exceeds secondary criteria for manganese)

(2) Perennial Yield − Current Use (Perennial Yield − Certificated Use)

* Portland Cement Association recommendations (19[illegible])

Note: All units are in acre-feet per year unless otherwise noted.

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HYDROLOGIC SUMMARY
PINE VALLEY, UTAH

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TABLE 4-28

interbedded with alluvial deposits. Shallow water-table conditions occur along Turkey Wash and Indian, Sheep, and Pine Grove creeks. These areas represent perched zones and are not indicative of the regional water table (Stephens, 1978). The valley-fill aquifer is at least 1300 feet (396 m) thick based on drillers' logs for wells completed in Pine Valley and the potentiometric surface ranges from 300 feet (91 m) to 400 feet (122 m) below the land surface. An aquifer test conducted by Ertec on an Air Force test well at (C-21-17)10aa gave an average transmissivity of 330 ft^2/day (31 m^2/day) and a storativity of about 0.002 after seven days of pumping at a sustained rate of 75 gpm (5 l/s).

There is little perennial stream flow in Pine Valley. Springs and spring-fed creeks represent the only source of perennial surface water, but they are not of sufficient magnitude to be considered a dependable source of water for the MX project.

Chemical analysis of 20 water samples collected by Ertec from creeks, ephemeral springs, perennial springs, wells, and a mine in the northern portion of the valley indicate that water quality meets the primary and secondary drinking water standards established by the State of Utah (Appendix B) in all cases except one. A water sample from Indian Creek (C-29-18)14ddd had a manganese concentration of 0.19 mg/l, which exceeds secondary drinking water standards. Water-quality data are not available for the southern part of Pine Valley, but it is expected that the ground-water would be potable and suitable for construction.

4.12.2 Water-Supply Sources

Development of the valley-fill aquifer through acquisition of new permits is the presently preferred MX water-supply source in Pine Valley (Table 4-29). The quantity of ground water presently available for development is about 6779 acre-ft/yr (8.36 hm^3/yr) (UWRL, 1980) after subtracting existing certificates and proofs of water rights from the basin perennial yield. This quantity of ground water is large compared to the peak-year MX water requirements of 2172 acre-feet (2.99 hm^3) in 1984 (Table 4-28). If a major portion of the pending applications are approved by the State Engineer prior to approval of the Air Force applications, the ranking of this water-supply option will change. However, the State Engineer could still grant the Air Force additional ground-water rights regardless of rulings on prior applications.

Importation of water to Pine Valley from Snake Valley is estimated to be the most costly (about 13 times the valley-fill alternative) and least timely (at least eight times longer than the valley-fill alternative) of the four water-supply options. It is estimated to take up to four months to install a pipeline and pumping stations from Snake Valley, the source of supply. The composite legal and physical availability of water from Snake Valley, however, would be higher than other options.

Development of the carbonate aquifer for water supply in Pine Valley has an overall ranking virtually equivalent that to importation of water and the lease/purchase option. Development

Criteria	Weight	Valley Fill Aquifer		Carbonate Aquifer		Lease Purchase		Importation	
		Score	Wt Score	Score	Wt Score	Score	Wt. Score	Score	Wt. Score
Legal Water Availability	10	10	100[1]	10	100	1	10[2]	8	80
Impacts on Man or Environment	10	9	90	8	80	9	90	5	50
Development Potential (Physical Availability)	10	3	30	3	30	3	30	10	100
Cost	4	10	40	3	12	7	28	1	4
Timeliness	6	10	60	2	12	9	54	1	6
Water Quality	2	10	20	10	20	10	20	10	20
Final Weighted Score			340*		254		232		260+

1 Does not include permits
2 Includes 60 rights and 30 use
* Recommended source of water supply
\+ First alternative source of water supply

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TABLE 4-29

of the carbonate aquifer is estimated to cost about one quarter that of importing water. Development of the carbonate aquifer is also estimated to be about two times more timely than construction of a conveyance system from Snake Valley to Pine Valley. Nevertheless, the potential for development of the carbonate aquifer in Pine Valley is considered low because of the presence of thick aquitards in the geologic section and the absence of both extensive rock fractures and a known regional flow system.

The lease or purchase of existing water rights is not recommended because there is presently insufficient water available. This option would become viable if a significant portion of the pending applications were granted prior to approval of MX appropriation applications

4.12.3 Suitable Areas for Water-Supply Well Locations

The primary and secondary areas for the construction of MX water-supply wells in Pine Valley, Utah, are shown in Drawing 4-11.

Three primary areas have been identified in Pine Valley. In the northern part of the valley, east of the Desert Experimental Range is a primary area of about 15 mi^2 (39 km^2). South of the lacustrine sediments, which occur in the north-central part of the valley, is an extensive primary area encompassing the central valley floor and alluvial fans. This area is bounded on the south by a 3- to 5-mile (5- to 8-km) wide endangered wildlife habitat area. To the south of this habitat

area is another small (less than 20 mi^2 [52 km^2]) primary area. This area is a considerable distance from any MX construction activities.

The available primary area in Pine Valley is extensive and is capable of providing a number of adequate well locations for the construction and operation of the MX system. Two of the five Air Force water-appropriation application points of diversion presently lie within a primary area. These are located at (C-30-17)12db (number 55021-1) and (C-28-17)5dd (number 55021-2).

A large area in the north-central part of the valley is classified as a secondary area because of lacustrine deposits in the subsurface. These sediments are of low permeability, and ground water within these deposits may be of poor quality. Another secondary area occurs on the west-central valley flank. Based upon the interpretation of available geophysical and water-level data, it appears that a 2- or 3-mile (3- or 5-km) wide area along the west side of the valley has shallow bedrock and small thicknesses of saturated valley-fill sediments.

Three of the five Air Force water-appropriation application points of diversion lie within secondary areas for water-supply well development. These are located at (C-27-16)18bd (number 55021-3), (C-26-17)10ad (number 55021-4), and (C-25-16)28bc (number 55021-5).

A number of 1 mi^2 (2.6 km^2) cultural exclusions for state lands occur throughout Pine Valley, excluding over 50 mi^2 (130 km^2) of the valley floor. In the northern part of the valley, all land within the Desert Experimental Range is excluded. Similarly, all land within the endangered wildlife area in Township 30S is excluded. A total of 10 existing wells or ground-water apropriations have also been identified as exclusionary areas (1-mile [1.6-km] radius from the point of diversion). In addition, six surface-water appropriations in (C-29-16) and (C-29-17) have been identified as exclusionary areas (0.5-mile [0.8-km] radius from the point of diversion). There are no known regional or known possible regional springs in Pine Valley. There are, however, a number of small local springs near the rock alluvial contact along the mountain front.

4.12.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are two viable MX water-supply alternatives for Pine Valley. Each of the alternatives is discussed below in order of priority.

4.12.4.1 Alternative I

The first alternative MX water-supply system in Pine Valley consists of the construction of one MX water-supply well at an existing point of diversion as filed by the Air Force as part of the appropriation application, the use of ground water from the existing Air Force test well at (C-26-17)10ad (number 55021-4), and the amendment of three pending points of diversion

to four more suitable drilling areas within the valley and the construction of four wells for water supply. Pending points of diversion can be split into two or more points and relocated, although the withdrawal rate and total annual quantity of withdrawal stated in the application cannot be exceeded. If exceeded, another application may have to be filed for the additional quantity, assuming that the water rights for the original application had already been granted.

The principal advantage of this approach is that the wells would be placed among the LSC, DTN, and cluster construction and operation which would minimize water conveyance costs. The primary disadvantages are that three of the five pending Air Force applications to appropriate ground water would have to be amended.

Five new wells would be constructed in Alternative I to satisfy the peak-year MX water requirements of 2172 acre-feet (2.68 hm^3) during 1984. This assumes that 300 gpm (19 l/s) can be achieved from each of the wells, or 483 acre-ft/yr (0.60 hm^3/yr) if pumped continuously. This well yield potential has been estimated by Ertec based on the available hydrogeologic information for the valley. The existing points of diversion and Alternative I recommendations are as follows:

EXISTING POINT OF DIVERSION	PROPOSED AMENDMENT
C-30-17-12db (number 55021-1)	South-central valley
C-28-17-5dd (number 55021-2)	South-central valley
C-27-16-18bd (number 55021-3)	No change
C-26-17-10ad (number 55021-4)	No change (existing well)
C-25-16-28bc (number 55021-5)	North-central valley
	North-central valley

The proposed LSC, presumed to be located at (C-26-19), will require from 180 to 1088 acre-ft/yr (0.22 to 1.34 hm^3/yr) with the peak requirement in 1986. Due to the expected moderately low well yields (300 gpm [19 l/s]) in the valley, an estimate of three water wells would be required to deliver the 675 gpm (43 l/s) needed for peak-water use at the LSC.

The LSC water requirement in the initial year of construction (1983) is only 180 acre-feet (0.22 hm^3) and this could be met with one well at a pumpage rate of only 112 gpm (7 l/s). In 1984 through 1986, however, the LSC water requirements increase to 573 acre-feet (0.71 hm^3), 747 acre-feet (0.92 hm^3), and 1088 acre-feet (1.34 hm^3), respectively. To provide adequate water supplies during this period, it is recommended that a water well be constructed at (C-27-16)18bd (number 55021-3) and the other two wells constructed in proximity to the LSC at amended points of diversion. A 300 gpm (19 l/s) well is equivalent to 483 acre-ft/yr (0.60 hm^3) if pumped continously. Therefore, two wells will be need in 1984 and 1985 and three wells in 1986 (as discussed above) to supply LSC water requirements.

Based upon the 15 May 1981 proposed DTN route and cluster locations, it would be possible to provide adequate groundwater supplies for the construction of the DTN and missile clusters through the construction of four new water-supply wells and the use of the existing Air Force well to meet the peak-year water requirement of 1742 acre-feet (2.15 hm^3) for nondomestic

purposes in 1984. In the initial year of construction (1983), only 470 acre-feet (0.58 hm^3) of water will be required for non-domestic purposes in Pine Valley. The existing well at (C-26-17)18ad (number 55021-4) is capable of supplying only 121 acre-feet (0.15 hm^3) of this requirement; however, additional water-supply wells in the south-central and north-central valley are recommended.

In 1987, LSC water requirements will decline to only 260 acre-feet (0.32 hm^3). This quantity can be met by pumping only one well.

4.12.4.2 Alternative II

The second alternative MX water-supply system consists of importing water from Snake Valley for LSC, DTN, and construction requirements in Pine Valley and the use of the existing Air Force test well at (C-26-17)10ad (number 55021-4). A 1350-gpm (81-l/s) well constructed in southern Snake Valley would be capable of supplying the entire LSC, DTN, and cluster water requirements in Pine Valley. This quantity of water would be equivalent to 2174 acre-ft/yr (2.68 hm^3/yr) if pumped continuously. Importation could be achieved via pipelines and pumping stations and water could be distributed to strategic locations for water supply in the valley. The existing Air Force test well could be used to supply water for nearby construction activities.

The primary advantage of this alternative is the elimination of the need to construct additional MX water-supply wells in

Pine Valley. The primary disadvantages are the high costs of delivery of water from Snake Valley to Pine Valley and the length of time required for the construction of a conveyance system

4.12.4.3 General Well Characteristics

The Air Force test well constructed in the valley-fill aquifer at (C-26-17)10ad was drilled to a depth of 951 feet (290 m) and has a 16-inch (41-cm) borehole and a 10-inch (25-cm) ID casing. This size of borehole and casing should be ample for production wells in Pine Valley. Although the depth to water ranges from 300 feet (91 m) in the northern part of the valley to over 650 feet (198 m) in the southern part of the valley, the depth to productive aquifers may be substantially greater. Therefore, it is recommended that MX water-supply wells be constructed to depths of at least 1200 feet (366 m). Due to the lack of hydrologic data concerning aquifer properties and well yield for much of Pine Valley, it is recommended that exploratory drilling be conducted to verify the adequacy of the locations of the MX water-supply wells.

4.12.5 Additional Investigations

Suggested possible sites for additional drilling and testing prior to operational development of the water-supply system are identified in Drawing 4-11 and are ranked in Table 4-30. The Air Force test well located at (C-26-17)10ad in northwest part of Pine Valley and the Pine Grove Associates Company wells in the southern part of the valley provide aquifer data in those

CRITERIA	POINTS OF DIVERSION						
		55021-2 28S-17W-5dd		55021-3 27S-16W-18bd		55021-4 + 26S-17W-10ad	
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	3	15	2	10	1	5
Proximity to Const. Camp or Plant	6	3	18	10	60	3	18
Proximity to DTN or Cluster	4	5	20	8	32	3	12
Sparse Data Area	10	4	40	10	100	0	0
Final Weighted Score			93		202 *		35

* Recommended additional drilling site(s) at points of diversion
\+ Existing Air Force test and observation wells

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CRITERIA	POINTS OF DIVERSION						
		55021 -5 25S-16W-28bc					
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	1	5				
Proximity to Const. Camp or Plant	6	2	12				
Proximity to DTN or Cluster	4	5	20				
Sparse Data Area	10	6	60				
Final Weighted Score			97				

* Recommended additional drilling site(s) at points of diversion

Point of diversion number 55021-1 was not considered due to its location in an excluded water supply area

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TABLE 4-30

parts of the valley. In the central valley area, few wells exist to provide aquifer data.

An additional drilling and testing site has been identified at the pending Air Force point of diversion at (C-27-16)18bd (number 55021-3) in central Pine Valley. This site is in a secondary water-supply area, and it is less than 0.25 mile (0.40 km) from a primary area (Drawing 4-11). A test well in this part of the valley is desirable because there are no aquifer or water-chemistry data within 5 miles (8 km). The site is adjacent to the DTN, there are clusters around it, and there is a proposed LSC in (C-27-16). Thus, this is a good location for a production well.

4.13 SPRING VALLEY

4.13.1 Hydrologic Summary

Spring Valley is a topographically closed basin situated in White Pine and Lincoln counties in eastern Nevada. It occupies an area of 1661 mi^2 (4302 km^2) of which 265 mi^2 (686 km^2) are considered suitable for MX deployment (Table 4-31).

The perennial yield of the basin is estimated at 100,000 acre-ft/yr (123.30 hm^3/yr) and storage within the upper 100 feet (30 m) of saturated sediment is estimated at 4.2 million acre-feet (5180 hm^3) (State of Nevada, 1971). Only 4781 acre-ft/yr (5.89 hm^3/yr) or about five percent of the perennial yield is presently being utilized (DRI, 1980). There are an additional 21,812 acre-ft/yr (26.90 hm^3/yr) in permitted and certificated water rights and 2594 acre-ft/yr (3.20 hm^3/yr) of pending applications for ground-water withdrawal in the valley (Woodburn and others, 1981).

The valley-fill aquifer in Spring Valley appears to be generally unconfined, although lacustrine clays may produce locally semi-confined to confined conditions. An aquifer test conducted by Ertec indicated significant well yield potential. The test well (9N/68E-30ab) produced 600 gpm (38 l/s) with only 14 feet (4 m) of drawdown.

The regional carbonate aquifer in Spring Valley is considered to have a high potential for development. Specific test data are not available for the carbonate aquifer, however, the lack of extensive volcanic or intrusive rock in the stratigraphic

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg. Valley Width	Suitable Area	Avg. Valley Floor Elevation
1661 sq mi	120 mi	14 mi	265 sq mi	5700 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	0-400 ft	5550-5850 ft	–	–

Perennial Yield	Ground-Water Recharge (ppt)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
100,000	75,000	2000	4000	70,000	–

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds * Standards	Suitable for Construction	Exceeds ** Standards
25	25	0	25	0

WATER USE AND APPROPRIATIONS

Source	Current Use	Applications	Certificates/ Proofs/Permits	Availability (1)
Ground Water	4781	2594	21,312	95,219/78,188
Surface Water	15,423	53,181	27,194	–

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction		176	629	298	253	72	0	0	0
Operation									

(1) Perennial Yield - Current Use / Perennial Yield - Certificated Use
* State and federal drinking water standards
** Portland Cement Association recommendations (19[illegible])

Note: All units are in acre-feet per year unless otherwise noted

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HYDROLOGIC SUMMARY SPRING VALLEY, NEVADA

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section and the presence of extensive faulting in carbonate rock units suggest that significant water production could be derived.

The surface water resource in Spring Valley, as reflected by present use, is significant. Several seasonal and perennial streams discharge from the flanks of the bordering mountain ranges. Many springs occur around the margins of the valley. All perennial surface water flows have been appropriated.

Twenty ground-water samples from wells and springs and five surface water samples were collected for chemical analyses. All samples were within criteria established for construction and also were within primary and secondary drinking water standards established by the State of Nevada.

4.13.2 <u>Water-Supply Sources</u>

Development of the valley-fill aquifer is the preferred water-supply source for Spring Valley (Table 4-32). The perennial yield of Spring Valley has been estimated by the Nevada State Engineer (1971) to be 100,000 acre-ft/yr (123.30 hm^3/yr). Considering approved ground-water rights, the quantity of ground water presently available is 78,188 acre-ft/yr (96.40 hm^3/yr) (Woodburn and others, 1981). This amount is very large compared to the peak-year MX construction requirement of 629 acre-feet (0.78 hm^3) in 1984. The aquifer test conducted by Ertec indicates that the valley-fill aquifer has a high physical potential for water development. The legal availability of water is also rated as high. Development of the valley-fill

Criteria	Weight	Valley-fill Aquifer		Carbonate Aquifer		Lease/ Purchase		Importation	
		Score	Wt. Score	Score	Wt. Score	Score	Wt. Score	Score	Wt. Score
Legal Water Availability	10	10	100	10	100	10	100	8	80
Impacts on Man or Environment	10	7	70	7	70	7	70	7	70
Development Potential Physical Availability	10	10	100	6	60	7	70	2	20
Cost	4	10	40	2	20	9	36	0	0
Timeliness	6	10	60	2	12	10	60	1	6
Water Quality	2	10	20	10	20	10	20	10	20
Final Weighted Score			360*		282		356+		186

* Recomended source of water supply
\+ First alternative source of water supply

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TABLE 4-32

aquifer is the least costly of the four water-supply options, is timely to develop, and is projected to have minimal impacts on existing users or the valley hydrologic system.

The lease or purchase of existing water rights is ranked second, although it received essentially the same overall score as development of the valley-fill aquifer. It is ranked second because the estimated cost is about 20 percent more than developing the valley-fill aquifer. In all other categories, this option scored the same as valley-fill aquifer development.

Although lease or purchase of existing water rights is a viable option, it is not likely that it would be implemented because of the significant availability of unappropriated ground water in Spring Valley.

Development of the carbonate aquifer ranked third because it is estimated to cost approximately five times more and take four times as long to construct as valley-fill aquifer development. This source of supply also has the lowest development potential of the three options.

Importation of water ranked fourth but is considered unnecessary. Spring Valley has been identified as a source of water exportation to water-short valleys because of the large quantity of available ground water.

4.13.3 Suitable Areas for Water-Supply Well Locations

The primary and secondary areas for the construction of MX water-supply wells in Spring Valley, Nevada, are shown in Drawing 4-12.

The available primary area in Spring Valley is limited in areal extent and is not located appropriately for proposed DTN and cluster construction activities. Two small primary areas have been delineated. In Township 11N, a narrow area of about 3 mi^2 (8 km^2) occurs along the alluvial fans. Another area of about 10 mi^2 (26 km^2) has been delineated in Townships 8N and 9N. Only one of the five Air Force water-appropriation application points of diversion lie within primary area for water-supply well development; this is at 8N-68E-4cc (number 41737).

Due to the extensive deposition of lacustrine deposits in Townships 10N and 11N and larger areas where shallow bedrock and limited saturated thickness of valley-fill sediments occur further to the south, most of the area within Spring Valley has been classified as secondary. A well yield of 600 gpm (38 l/s) has been obtained from the Air Force test well at 9N-68E-30ab in a secondary area. This indicates that portions of the secondary areas can be utilized and are capable of providing the necessary water yield for MX construction activities, although primary areas are still estimated to have greater potential well yields. One of the five air Force water-appropriation application points of diversion lie within secondary area for water-supply well development at 9N-68E-30aa (number 41738).

Only one fee-land and two COE (Code 1) recommended exclusion areas occur within the valley are being considered for DTN and cluster locations. There are however, 24 ground-water appropriation exclusion areas (a 1-mile [1.6-km] radius from the point

of diversion or well location) and six surface water appropriation exclusion areas (a 0.5- or 1-mile [a 0.8- or 1.6-km] radius from the point of stream diversion or spring location, respectively). There are no known regional or known possible regional springs within Spring Valley. Three of the five Air Force water-appropriation application points of diversion lie within areas excluded for water-supply well development. These are located at 10N-67E-7ba (number 41739), 8N-68E-12ca (number 41736), and 10N-67E-34ab (number 41735).

4.13.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are two viable MX water-supply system alternatives for Spring Valley. These alternatives are discussed below in order of priority.

4.13.4.1 Alternative I

This alternative consists of the construction of two water-supply wells near pending points of diversion on the northwest flank of the valley and the use of the existing Air Force well at 9N-68E-30aa (number 41738).

This plan will provide good overall distribution of MX water supply. The existing points of diversion at 10N-67E-34ab (number 41735) and 10N-67E-7ab (number 41739) are both located in shallow bedrock exclusion areas less than 1 mile (1.6 km) from secondary drilling area. It is recommended that these points of diversion be relocated to sites 1 to 2 miles (1.6 to

3 km) east of their present locations. It is estimated that wells at these ammended locations should be capable of producing at least 250 gpm (16 l/s). If this yield can be developed, pumpage at the existing test well can be reduced accordingly. The major disadvantage of this approach is that additional well construction would be required and amendment of two pending points of diversion would be necessary.

4.13.4.2 Alternative II

This alternative consists of the use of the existing Air Force test well at 9N-68E-30aa (number 41738) as a single water-supply source.

There is no LSC scheduled for Spring Valley. The annual water requirement for DTN and cluster construction ranges from 72 to 629 acre-feet (0.09 to 0.78 hm3) during the construction period. The entire MX water requirement may be met by the existing Air Force test well which is capable of producing 968 acre-ft/yr (1.19 hm^3/yr) at the rate of 600 gpm (38 l/s).

The primary advantage of this approach is that no additional MX water-supply wells would be required in Spring Valley. The main disadvantage is that an extensive water distribution system would be required.

4.13.5 Additional Investigations

Possible sites for additional drilling and testing prior to operational development of the water-supply system are identified on Drawing 4-12 and are ranked in Table 4-33. The Air

CRITERIA		POINTS OF DIVERSION					
		41737 8N 68E 4cc		41738 + 9N-68E 30aa			
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	6	30	6	30		
Proximity to Const. Camp or Plant	6	0	0	0	0		
Proximity to DTN or Cluster	4	9	36	7	28		
Sparse Data Area	10	4	40	0	0		
Potential Impact [illegible]	10	1	10	1	10		
Total Weighted Score			116		68		

[illegible] additional [illegible] site(s) at points of diversion
[illegible] well[illegible]

[illegible] 41736, 41735 and 41734 were not considered
[illegible] water-supply areas

[illegible] drilling and testing site has been selected at 10N-68E-[illegible]
[illegible] suitable for investigation exist. This site
is [illegible]

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ADDITIONAL DRILLING/TESTING SITE MATRIX SPRING VALLEY, NEVADA

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TABLE 4-33

Force test well located in southern Spring Valley at 9N-68E-30aa has been tested and the data evaluated to provide information concerning the valley-fill aquifer in this part of the valley. In north-central Spring Valley, stock wells provide insufficient data to fully evaluate aquifer conditions.

In the northern half of Spring Valley, no points of diversion exist which are suitable for additional drilling. A site has been selected east of point of diversion (number 41735) and is positioned along an existing road in a secondary water-supply area (Drawing 4-12). It is located at 10N-67E-36bb, approximately 5.5 miles (9 km) north of the existing Air Force test well. A ground-water divide occurs between the site and the Air force test well. The DTN is not located in the northern part of the valley but several clusters are in proximity of the site.

The pending point of diversion at 8N-68E-4cc (number 41737) is not recommended for additional drilling and testing prior to operational development of the water-supply system because it is only about 4 miles (6 km) south of the Air Force test well.

4.14 WAH WAH VALLEY

4.14.1 Hydrologic Summary

Wah Wah Valley is a north-south trending, topographically closed basin in Millard and Beaver counties, Utah. Of the 600 mi^2 (1554 km^2) of valley area, 240 mi^2 (622 km^2) are suitable for MX deployment (Table 4-34). Ground water in the basin is sparsely developed. Certificates and proofs have been granted for withdrawal of only 34 acre-ft/yr (0.42 hm^3/yr) (DRI, 1980) of the 10,000 acre-ft/yr (12.33 hm^3/yr) of estimated perennial yield (Price, 1979) of the ground water basin, but there are 32,576 acre-ft/yr (40.16 hm^3/yr) of ground-water appropriation permits and applications (DRI, 1980). Present ground-water use is estimated at only 2 acre-ft/yr (0.001 hm^3/yr) (UWRL, 1980). Price (1979) estimates the amount of ground water in storage in the upper 100 feet (30 m) of saturated sediment in Wah Wah Valley at 0.8 million acre-feet (986.4 hm^3). Withdrawal of the peak-year MX water requirement of 3194 acre-ft/yr (3.94 hm^3/yr) in 1984 would represent only a small percentage of the ground water in the basin unless a significant portion of the ground-water appropriation applications are approved and withdrawal starts prior to 1987, the last year MX withdrawals for construction are expected in Wah Wah Valley.

Based on examination of drilling logs, the valley-fill aquifer in Wah Wah Valley appears to be largely unconfined. The presence of lacustrine clays may produce locally confined or semiconfined conditions, such as those found at Wah Wah Hardpan,

GENERAL PHYSIOGRAPHY

Valley Area	Valley Length	Avg. Valley Width	Suitable Area	Avg. Valley Floor Elevation
[illegible]00 sq mi	44 mi	14 mi	240 sq mi	4800 ft

GENERAL HYDROLOGY

Aquifer	Depth to Water	Potentiometric Elevation Range	Transmissivity	Storativity
Valley-fill	200-600 ft	4460-4800 ft	12,000 sq ft/day	0.14

Perennial Yield	Ground-water Recharge (est)	Interbasin Recharge	Interbasin Discharge	ET	Surface Discharge
10,000	7000	3000	8500	640	500

WATER QUALITY

Total Samples	Suitable for Consumption	Exceeds (1) Standards	Suitable for Construction	Exceeds (2) Standards
16	10	6	14	2

WATER USE AND APPROPRIATIONS

Source	Current Use	Permits/ Applications	Certificates/ Proofs	Availability (3)
Ground Water	2	32,575	34	19998 19966
Surface Water	50	900	23.	–

MX WATER REQUIREMENTS

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction Operation	0	587	3194	1954	2264	371	0	0	0

Six samples exceed criteria as follows: 4 - fluoride, 3 - calcium, 2 - magnesium, 2 - chloride, 2 - sulfate, 1 - sodium
Two samples exceed TDS construction criteria. Portland Cement Association recommendations (1966).
Perennial Yield - Current Use; Perennial Yield - Certificated Use

Note: All units are in acre-feet per year unless otherwise noted.

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HYDROLOGIC SUMMARY
WAH WAH VALLEY, UTAH

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located near the center of the basin (C-25-13). An aquifer pumping test conducted by Ertec at a constant rate of 375 gpm (24 l/s) indicated an aquifer transmissivity of 12,000 ft^2/day (1580 m^2/day). Preliminary numerical modeling of the basin by Ertec suggests a similarly high transmissivity of 14,000 ft^2/day (1300 m^2/day), which is considered representative of the entire basin. A storativity of at least 0.14 is indicated by the aquifer test results.

Water from the valley-fill aquifer locally does not meet drinking water or construction-use standards. This problem is mostly restricted to the central axis of the valley, particularly in or near Wah Wah Hardpan. Wells drilled in the valley-fill aquifer away from Wah Wah Hardpan should meet construction standards and wells drilled in the valley-fill aquifer away from the valley axis should generally meet both construction and drinking water standards.

The regional carbonate aquifer, underlying and adjacent to the valley-fill aquifer, is considered to have a low potential for development in Wah Wah Valley. Data are notably sparse with respect to the carbonate aquifer in Wah Wah Valley, but the extensive occurrence of volcanic and intrusive rocks, the absence of a recognized regional flow system, and the absence of extensive faulting all suggest a low potential for ground-water development of the aquifer.

4.14.2 Water-Supply Sources

The acquisition of new permits and the construction of water wells in the valley-fill aquifer is the presently preferred MX water-supply source in Wah Wah Valley (Table 4-35). The ranking of this water-supply option could change if the pending applications for ground-water rights are granted prior to those of the Air Force. However, the Utah State Engineer could still grant the Air Force additional ground-water rights regardless of the ruling on prior applications. The amount of ground water currently available for development (9998 acre-ft/yr [12.33 hm^3/yr] considering existing use, and 9966 acre-ft/yr [12.29 hm^3/yr] considering approved ground-water rights) is large compared to the estimated peak-year MX use of 3194 acre-ft/yr (3.94 hm^3/yr). Aquifer tests indicate that the valley-fill aquifer has substantial ability to store and transmit water, thus, there is a high physical potential for water development in addition to the high legal availability of water. In addition, this option is the least costly and the most timely of the four choices.

Importation of water, the second-ranked, water-supply source, would not appear to be necessary because of the availability of water (unappropriated perennial yield) in the valley. In addition, importation of water would be costly (over 12 times the valley-fill option), would take more time (about 16 times longer than the valley-fill option) than the other options, and may have negative impacts on the basins used as a source of water.

Lease or purchase of existing water rights is presently not recommended because there are only 34 acre-ft/yr (0.04 hm^3/yr)

Criteria	Weight	Valley-Fill Aquifer Score	Valley-Fill Aquifer Wt. Score	Carbonate Aquifer Score	Carbonate Aquifer Wt. Score	Lease/Purchase Score	Lease/Purchase Wt. Score	Importation Score	Importation Wt. Score
Legal Water Availability	10	10	100	10	100	3	30	8	80
Impacts on Man or Environment	10	7	70	7	70	6	60	5	50
Development Potential (Physical Availability)	10	7	70	3	30	6	60	10	100
Cost	4	10	40	3	12	7	28	1	4
Timeliness	6	10	60	2	12	7	42	1	6
Water Quality	2	10	20	10	20	10	20	10	20
Total Weighted Score			[illegible] *		244		240		270 +

* Recommended source of water supply
\+ First alternative source of water supply

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WATER-SUPPLY SOURCE MATRIX
WAH WAH VALLEY, UTAH

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of approved ground-water rights and 251 acre-ft/yr (0.31 hm^3/yr) of approved surface water rights, the total of which is far less than that needed for MX purposes. This option would become viable and perhaps necessary only if a significant portion of the pending ground-water applications were approved ahead of the MX applications.

Extraction of water from the carbonate aquifer is ranked low because of the presumed low potential for development, the very high cost (about three times the valley-fill option) for development, and the longer period of time (four times the valley-fill option) necessary to develop this aquifer compared to the valley-fill aquifer.

4.14.3 Suitable Areas For Water-Supply Well Locations

The primary and secondary areas for the construction of MX water supply wells in Wah Wah Valley, Utah, are shown in Drawing 4-13.

Due to the extensive deposition of lacustrine sediments throughout most of Wah Wah Valley, only a small area in the southern part of the valley is classified as primary. The available primary area is too limited in areal extent to provide the entire water requirement. None of the seven Air Force water-appropriation application points of diversion lie within a primary area for water-supply well development.

There are extensive secondary areas available in Wah Wah Valley for the construction of MX water supply wells (Drawing 4-13). The lacustrine sediments which occur throughout most of the

valley may overlie coarser-grained sediments which comprise productive aquifers. Five of the seven Air Force water-appropriation application points of diversion lie within secondary areas for water-supply well development. These are located at (C-27-14)20db (number 55019-2), (C-26-14)25ac (number 55019-3), (C-26-13)7ac (number 55019-4), (C-25-14)23dc (number 55019-5), and (C-24-13)31db (number 55019-7).

A number of 1-mi^2 (2.6-km^2) state land cultural exclusions occur throughout Wah Wah Valley and, east of Wah Wah Ranch, about 10 mi^2 (26 km^2) of fee land is also excluded. A total of seven existing wells or ground-water appropriations have also been identified as exclusionary areas (1-mile [1.6-km] radius from the point of diversion). Five of these water-appropriation exclusions are located in the southern portion of the valley and two are located in the northern end of the valley near the Wah Wah Hardpan. Wah Wah Spring, located near the rock-non-rock boundary on the west-central side of the valley (C-27-15)11aba has been identified by Ertec as a regional spring on the basis of the criteria discussed in Section 3.2. Based upon the results of numerical modeling, no reduction in discharge from Wah Wah Spring due to MX ground-water withdrawals from the valley-fill aquifer is expected to occur if MX water-supply wells are set back a minimum of 3 miles (5 km). All areas within 3 miles (5 km) of the spring have therefore been excluded from further consideration. Two of the seven Air Force water appropriation application points of diversion lie within excluded area for

water-supply well development. These are at (C-28-14)15bc (number 55019-1), and (C-25-14)3ca (number 55019-6).

4.14.4 Water-Supply System Alternatives

Based upon the available hydrologic data and the matrix analyses conducted as part of this investigation, there are three viable MX water-supply system alternatives for Wah Wah Valley. Each of the alternatives is discussed below in order of priority.

4.14.4.1 Alternative I

The Air Force has filed applications for seven points of diversion in Wah Wah Valley. The preferred MX water-supply system in Wah Wah Valley consists of the construction of four MX water-supply wells at the existing application points of diversion, the amendment of the point of diversion filed at the unproductive Air Force test well at (C-26-14)25ac to the productive Air Force test well at (C-27-14)28dd, and the amendment of the point of diversion located at (C-25-14)3ca to a more suitable drilling area.

This is the preferred approach since minimal modification of the existing water appropriations would be required and no delays in obtaining approval for the majority of the Air Force water-appropriation applications would occur. The primary disadvantage is that water for the construction of the DTN would likely have to be distributed via pipeline or water trucks to storage areas (reservoirs) at more strategic water-supply locations, perhaps along DTN routes or entrance roads to clusters.

The proposed LSC, presumed to be in (C-26-14) will require from 154 to 877 acre-ft/yr (0.19 hm^3/yr) with the peak requirement in 1986. Two water-supply wells will be required to provide the 95 to 544 gpm (6 to 34 l/s) required for use at the LSC. The existing Air Force test well at (C-27-14)28dd, which has been tested at 375 gpm (24 l/s), can be used to provide the LSC water requirements for 1982, but it will be necessary to transfer one of the existing Air Force appropriation application points of diversion to the well. It is recommended that the pending Air Force application to appropriate ground water from the point of diversion at (C 26-14)25ac (number 55019-3) at the unproductive Air Force test well in north-central Wah Wah Valley be amended to the productive well site. For the period 1983 to 1986, an additional well will be required. The pending point of diversion at (C-27-14)20db (number 55019-2) is proximal to the LSC site and could be used as a source of water for both the LSC and the clusters in the southern part of the valley during the peak LSC water-use period. In 1987, only one production well will be required and the existing Air Force test well should suffice.

Based on the available data on the hydrologic characteristics of Wah Wah Valley, it will be possible to provide adequate ground-water supplies for the construction of the DTN and missile clusters with five new water-supply wells and the use of the existing Air Force test well. In the initial year of construction, (1983) only 502 acre-feet (0.62 hm^3) of water will be required for nondomestic purposes in Wah Wah Valley. The existing test well at (C-27-14)28dd is capable of supplying 604 acre-feet

(0.74 hm^3). In 1984, 2653 acre-feet (3.27 hm^3) will be required for nondomestic purposes with the majority required for revegetation (920 acre-feet [1.13 hm^3]) and road compaction (1120 acre-feet [1.38 hm^3]). It is recommended that the pending points of diversion at (C-27-14)20 (number 55019-2), (C-26-13)7 (number 55019-4), (C-25-14)23 (number 55019-5), and (C-24-13)31 (number 55019-7) be used as locations for MX water-supply wells. In addition, the pending point of diversion at (C-25-14)3 (number 55019-6) should be amended from its present location, within an excluded area, to a more suitable site to accommodate the combined peak-year domestic and construction water requirement of 3194 acre-feet (3.94 hm^3).

In 1985 and 1986, MX nondomestic water requirements are estimated to be 1218 and 1232 acre-feet (1.50 and 1.52 hm^3), respectively. This reduced water requirement can be met by either reducing the pumpage at each MX water-supply well or reducing the number of pumping wells. Because the majority of the water requirements in 1984 will be for revegetation, roadway dust control, and shelter construction and will be needed throughout the valley, it is recommended that pumpage be reduced from each MX water-supply well and that all wells remain operational.

In 1987, the MX nondomestic construction water requirements will further decline to only 290 acre-feet (0.36 hm^3). Although the area of use for this water has not been determined, one well located at the LSC and one well near the final construction areas should suffice.

4.14.4.2 Alternative II

The second alternative MX water-supply system in Wah Wah Valley consists of the amendment of five pending appropriation points of diversion from their present location to sites along the proposed DTN near the entrances to cluster roads, and the amendment of the point of diversion filed at the unproductive Air Force test well at (C-26-14)25ac (number 55019-3) to the productive Air Force well at (C-27-14)28dd.

The principal advantage of this approach is a better distribution of wells for DTN and cluster construction with minimal piping or transport of water. The primary disadvantage is that amendment of six of the seven pending appropriation applications would be required and could delay the approval of the Air Force water-appropriation applications.

4.14.4.3. Alternative III

The third alternative MX water-supply system consists of the augmenting of either Alternative I or II with the lease, or, if necessary, the purchase of water rights from mining interests in the southern part of the valley.

Two high-production, deep water wells have been constructed at (C-28-14)10 and (C-28-14)11ab for a potential alunite mine. Well tests conducted in 1974 indicated that each well is capable of producing over 1300 gpm (82 l/s) (Utah State Engineer's office, 1981). Ground-water appropriation applications have been filed with the State Engineer's office to use these wells as a water-supply source for a proposed alunite mine in southwestern

Wah Wah Valley. The Utah State Engineer has not yet approved these applications. The wells are located about 6 miles (10 km) south of the proposed LSC and could be used to supply the entire LSC water requirement as well as DTN and cluster requirements in the southern half of the valley. For the northern half of the valley, the points of diversion recommended for either Alternative I or II could be used.

4.14.4.4 <u>General Well Characteristics</u>

The yield of MX water-supply wells will depend upon the hydrologic characteristics of the aquifer(s) penetrated, well design, and to a lesser degree, the depth to static water and the productive aquifer(s). Recorded yields for existing wells in the valley range from nil at the 1251-foot (381-m) deep Air Force exploratory well at (C-26-14)25ac to 1353 gpm (85 l/s) at the 1475-foot (450-m) deep test well at (C-26-14)11abb. The Air Force test well at (C-27-14)28dd, which was drilled to a depth of 1350 feet (411 m) with a 16-inch (41-cm) boring and a 10-inch (25-cm) ID casing, yielded 375 gpm (24 l/s).

The depth to the potentiometric surface ranges from about 200 feet (61 m) below the land surface in the northern and central parts of the valley to 800 feet (244 m) below the land surface in the southernmost part of the valley. The depth to productive aquifers may be substantially greater. Significant well yields are documented in the southern part of the valley. Much lower well yields are probable in the central and northern parts of the valley, but the aquifer properties here are unverified.

It is recommended that exploratory drilling be done in conjunction with the selection of any MX water-supply wells in the northern part of the valley.

4.14.5 Additional Investigations

Possible sites for additional drilling and testing prior to operational development of the water-supply system are identified in Drawing 4-13 and are ranked in Table 4-36.

Additional data from drilling and testing in central and northern Wah Wah Valley are needed to supplement the small amount of available data. The first priority for additional drilling is located at (C-26-14)4ad in west-central Wah Wah Valley (Drawing 4-13). This site is located on an alluvial fan 3 miles (5 km) northwest of a proposed construction plant and 4.5 miles (7 km) west of the unproductive Air Force test well drilled in the valley-fill lacustrine deposits. The site is in an area where there is a limited thickness of saturated valley-fill sediments due to the presence of volcanics in the subsurface. When the unproductive nature of the lacustrine deposits in the central part of the valley is considered, the proposed site is in the most favorable area for determining if a viable water supply can be developed in central Wah Wah Valley. The site is also centrally located in an area of clusters and is 1.5 miles (2 km) west of the DTN.

The second priority for additional drilling is pending Air Force point of diversion number 55019-7 which is located in northwestern Wah Wah Valley. Two other pending Air Force points of

CRITERIA	POINTS OF DIVERSION						
		55019-2 (C-27-14)20db		55019-3 + (C-26-14)25ac		55019-4 (C-26-13)7ac	
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	4	20	1	5	1	5
Proximity to Const. Camp or Plant	6	5	30	10	60	7	42
Proximity to DTN or Cluster	4	3	12	5	20	5	20
Sparse Data Area	10	2	20	2	20	6	60
Final Weighted Score			82		105		127

* Recommended additional drilling site(s) at points of diversion

\+ Existing Air Force observation well

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TABLE 4-36

CRITERIA	POINTS OF DIVERSION						
		55019-5 (C-25-14)23dc		55019-7 (C-24-13)31db			
	weight	score	weighted score	score	weighted score	score	weighted score
Yield Potential	5	1	5	1	5		
Proximity to Const. Camp or Plant	6	5	30	0	0		
Proximity to DTN or Cluster	4	7	28	8	32		
Sparse Data Area	10	10	100	6	60		
Final Weighted Score			163		97 *		

* Recommended additional drilling site(s) at points of diversion

PointS of diversion number 55019-1 and 55019-6 were not considered due to their location in an excluded water-supply area.

An additional drilling and testing site has been selected at (C-26-14)4ad where no points of diversion suitable for investigation exist. This site is located near a proposed construction camp in a sparse data area.

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TABLE 4-36

diversion, numbers 55019-4 and 55019-5, were ranked higher but were not considered due to their location in similar hydrologic settings to the existing unproductive Air Force well. The proposed site is located at (C-24-13)31db within a secondary water-supply area since no primary areas exist in the northern half of the valley. Aquifer data are limited to one stock well located 3 miles (5 km) east of the site. Testing of the valley-fill aquifer at this point of diversion would provide valuable information about aquifer response to pumping in northern Wah Wah Valley. This site is 1.5 miles (2 km) from the DTN, which would facilitate construction activities should the site be used as an MX water supply.

5.0 MONITORING PROGRAM

5.1 INTRODUCTION

This section of the report provides general guidelines and criteria for designing an effective, valley-specific water monitoring system. Such a monitoring system will be designed and implemented as part of the Air Force Water Resources Program for fiscal year 1982.

A hydrological monitoring network will be needed throughout the MX deployment and OB areas in order to obtain a record of the effects of MX ground-water withdrawals on existing wells, springs, other hydrologic features and on the general environment of these areas. These records will help protect the Air Force from spurious claims concerning the effects of MX wells. If any indications of detrimental effects should ever appear, the monitoring data will be needed to determine the most appropriate mitigating action.

When water is withdrawn from a well, the aquifer is stressed. The magnitude and extent of the stress depend on several factors including withdrawal rates and duration of pumping, type of aquifer, various aquifer hydraulic coefficients, and locations and quantities of recharge and natural discharge. Because knowledge about these factors is never complete, the magnitude of stress at a given location in the aquifer, as represented by water-level changes, can be determined only by actual observation at a monitoring well. A number of monitoring wells will be needed to determine the precise change in water level throughout

a valley and the resultant effects on springs and wetlands caused by pumping from an MX well or well field. However, it will not be necessary to know precisely the change of water level due to pumping at every point in a valley. If water-supply wells are located wisely, relatively few monitoring stations will be required in each valley to obtain the necessary data.

5.2 GENERAL CRITERIA AND GUIDELINES

A hydrologic site should be monitored only if there is a specific purpose for the resulting data. Some of the purposes for monitoring stations in the MX deployment valleys are listed in Table 5-1. Monitoring at a point insensitive to MX pumping is necessary in order to separate the effects of pumping MX wells from natural and man-made effects. Whenever possible, a monitoring well should be located where data from it can be used for multiple purposes. Monitoring wells can usually be located anywhere within a relatively broad area in order to obtain the desired information.

5.2.1 Monitoring Well Selection and Construction

To the greatest degree possible, monitoring wells should be selected first from suitable private and public wells, especially those monitored by the U.S. Geological Survey (USGS) and second from new wells constructed after it has been determined that existing suitable wells are unavailable. New wells should be drilled to the minimum depth in the aquifer that corresponds to the mid-point of the screened section of the MX production

PURPOSES OF MONITORING STATIONS IN MX DEPLOYMENT VALLEYS

- TO DETERMINE THE MAGNITUDE OF WATER–LEVEL CHANGE AT EXISTING PUMPED WELLS
- TO MEASURE THE EFFECT OF PUMPING ON VALLEY–FLOOR SPRINGS
- TO MEASURE THE EFFECT OF PUMPING ON REGIONAL CARBONATE SPRINGS
- TO MEASURE THE EFFECT ON SPRINGS AROUND THE PERIPHERY OF THE VALLEY AND IN THE NEARBY MOUNTAINS
- TO DETERMINE THE EFFECT ON PHREATOPHYTE AND WILDLIFE REFUGE AREAS
- TO DETERMINE THE MAGNITUDE OF THE WATER–LEVEL DECLINES NEAR THE WITHDRAWAL WELLS
- TO DETERMINE THE EFFECTS OF CONSTRUCTION ON STREAMS AND GROUND–WATER RECHARGE
- TO OBTAIN A RECORD OF WATER–LEVEL FLUCTUATIONS AT A POINT IN THE VALLEY WHERE THE AQUIFER IS INSENSITIVE TO MX PUMPING

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PURPOSES OF MONITORING STATIONS
IN MX DEPLOYMENT VALLEYS

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TABLE 5-1

wells being monitored. The wells can have either steel or plastic casing. The bottom 20 feet (6 m) of casing should be perforated where the aquifer materials are fairly uniform. However, the entire length of casing in the saturated zone should be perforated where there are beds of clay or clay mixtures exceeding about 5 feet (1.5 m) in thickness interspersed throughout the aquifer.

Most of the monitoring wells should be open to the same aquifer as the MX production wells. However, in valleys having perched aquifers, additional monitoring wells will be needed in perched aquifers which are usually unconnected, or poorly connected, hydraulically with the developed aquifer. Also, there may be valleys in which the carbonate (regional) aquifer should be monitored when the principal valley-fill aquifer is tapped or vice versa. Monitoring wells will be needed in such valleys only when there is evidence of a hydraulic connection between the two aquifers and when springs are known to be discharging from the carbonate aquifer.

5.2.2 Quality of Water

The quality of both surface and ground water is not expected to be affected adversely anywhere within the MX deployment area due to Air Force activities. The principal ground-water recharge areas are in the mountains and on the upper reaches of alluvial fans. These areas lie above the areas that will be impacted by MX construction and installations; therefore, there will be little, if any, contamination by recharge from MX activities.

Most of the withdrawal from a well or well field will be during a maximum construction period of about three years, a very short period of time in terms of the usual rate of movement of ground water. Thus, pumping will likely have a negligible effect on the natural ground-water flow patterns and, consequently, the quality of water. For this reason, it will not be necessary to do intensive monitoring of ground-water quality except at the MX production wells. A moderate amount of ground-water sampling and a minor amount of surface water and spring sampling will be needed as explained in Section 5.3.

Some special attention is needed if ground water of poor quality is located within the anticipated range of influence of an MX production well. Pumping at the well could cause the poor quality water to migrate to the production well. A well for monitoring water quality should be located between the poor quality water and the production well in order to monitor migration and to take steps in intercept it if necessary.

5.2.3 Frequency of Monitoring

The frequency of monitoring depends largely on the factors in Table 5-2. The frequency will range from continuous measurement of water-level fluctuations in wells and flow rates in springs and streams at some sites to a one-time sampling of the quality of water at some wells and springs. Monitoring should be more frequent during the preconstruction and construction phases than during the operational phase for two reasons. First, the natural cyclic water-level pattern must be determined for the

FACTORS DETERMINING FREQUENCY OF MONITORING

- SPECIFIC PURPOSE FOR THE PARTICULAR MONITORING SITE
- PARAMETER BEING MONITORED
- DISTANCE OF THE MONITORING SITE FROM THE MX WELL FIELD
- DISTANCE OF THE MONITORING SITE FROM EXISTING WELLS AND WELL FIELDS
- KNOWLEDGE ABOUT THE NATURAL CYCLIC MAGNITUDE AND PERIOD OF THE PARAMETER BEING MONITORED
- DISTANCE OF MX WELL FIELD FROM SENSITIVE ENVIRONMENTAL FEATURES
- HYDRAULIC CHARACTERISTICS OF THE AQUIFER IN THE VICINITY OF THE MX WELL FIELD AND POTENTIALLY SENSITIVE FEATURES

preconstruction phase to obtain a base record against which hydrologic data obtained during later periods can be compared. Second, the largest withdrawals and the greatest stress on the hydrologic system will occur during the construction phase; therefore, if any adverse effects occur, it will be during this phase. The monitoring frequencies for the various parameters and site locations are given in Section 5.3.

5.3 SPECIFIC GUIDELINES

A principal assumption in the derivation of the specific guidelines is that MX pumpage in a given valley will be from one well or one well field. If pumpage from some valleys is at two or more isolated wells or well fields, the monitoring network for one well field may overlap the network from a nearby well field, thus the monitoring network in those valleys will have to be modified accordingly. The manner of integrating the network is discussed in the following subsections where the various types and locations of monitoring sites are explained.

5.3.1 Wells

5.3.1.1 Observation Well to Monitor Natural Water Levels

A record of water-level fluctuations from natural causes or pumping from other existing wells, and virtually unaffected by MX pumping, will be needed in order to determine the effects of pumping the MX wells. An observation well may be needed in each valley and should be at least 3 miles (5 km) from all wells yielding more than about 100 acre-ft/yr (0.12 hm^3/yr) and sufficiently distant or isolated from MX production wells to be unaffected by them.

Continuous recorders should be operated on the observation wells during the preconstruction and construction phases. The recorders may be removed from wells where pumping has had no observable effect by the end of the construction phase. However, recorders should be maintained on wells where an effect or apparent effect has been observed. After recorders are removed, periodic water-level measurements should be made semiannually (at the annual high and low water-level periods), and this schedule should be continued until the end of the operation phase or until pumping has ceased at the associated MX production wells, whichever is later.

5.3.1.2 Pumped Well

All MX pumped wells should be equipped with a totalizing water meter. The meter reading should be recorded monthly, and the water level in the pumped well should be measured each time the pumpage is recorded. Water samples should be collected from MX production wells when they are first installed and from existing wells that are converted to MX use when they are first used for construction. The production wells should be sampled annually as long as they are pumped. The parameters and chemical constituents to be measured are listed in Table 5-3. Water sampling will cease when pumping stops, but water-level measurements will be made at semiannual intervals as at the observation wells.

5.3.1.3 Observation Well Near MX Well Field

Water levels should be monitored at one observation well within a radius of about 0.5 mile (1 km) of each MX production well

SUGGESTED WATER QUALITY CONSTITUENTS AND PARAMETERS TO BE DETERMINED

MEASURE IN FIELD

TEMPERATURE

pH

CONDUCTIVITY

MEASURE IN LABORATORY

SILICA

CALCIUM

MAGNESIUM

SODIUM

POTASSIUM

BICARBONATE

CARBONATE

SULFATE

CHLORIDE

NITRATE

TOTAL DISSOLVED SOLIDS

Note: There may be special situations or valleys where other constituents should be monitored. The other constituents may be identified during the comprehensive chemical analysis performed on initial samples from MX production wells. They may also be identified when accumulated monitoring data suggests a special need.

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SUGGESTED WATER-QUALITY CONSTITUENTS AND PARAMETERS TO BE DETERMINED

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TABLE 5-3

or well field. The frequency of measurement should be monthly during the preconstruction and construction phases and semi-annual (at the annual high and low water-level periods) after pumping for construction has ceased unless there is a special need for more frequent monitoring. Measurements should be continued one year after the end of the operational phase. If the observation well is also used to monitor the change in water quality, samples should be collected and processed in the manner described above for a pumped well.

5.3.1.4 Observation Well to Monitor Effects on Existing Wells

An observation well that is used to monitor effects of MX pumping on existing wells should be between the existing wells and the MX well or well field, and it should be nearer to the existing wells than it is to the MX production well(s). The observation well might even be an existing well if precise effects are needed at the well or if the existing well is available and suitable for monitoring. Where an existing well is being monitored by the USGS, it would be highly desirable to include it in the MX monitoring program. The resulting duplicate records can be used to both enlarge the data base and to evaluate the accuracy and reliability of the MX monitoring program. The minimum monitoring frequency should be monthly during the preconstruction and construction phases and semiannual (at the annual high and low water-level period) during the operation phase and for one year after operations cease.

5.3.1.5 Observation Well to Monitor Effects on a Spring

A well used to monitor the effects of MX pumping on a valley floor spring should be within a few hundred feet of and upgradient from the spring. The observation well should have dual completion, one piezometer to monitor the main part of the principal aquifer supplying the spring and one piezometer to monitor the near-surface part of the aquifer. The purpose of two piezometers is to monitor both long-term and diurnal fluctuations. The piezometers should be equipped with continuous recorders during the preconstruction and construction phases and during any period that recorders are used in monitoring spring discharge. An observation well would not usually be needed near a spring that is measured periodically; however, if an observation well is monitored near such springs, the water level should be measured at the same time that the spring flow is measured. Once a correlation is established between the water level in the well and spring discharge (probably by the end of the MX construction in the valley), the well recorder can be removed and a tape measurement of water level in the well made each time that the spring recorder is visited and serviced. When pumping at the associated MX well field ceases, the monitoring schedule then in use should be continued for one year and then terminated unless a need arises for continuing the monitoring program.

5.3.2 Springs

Pumping of MX wells may have an adverse effect on the discharge of some valley floor springs, but the pumping probably will not have an adverse effect on any of the springs near the periphery

of the valleys and in the mountains. Many of the valley floor springs discharge from the same aquifer that will be tapped by the wells, whereas, the springs near the periphery of the valleys and in the mountains discharge from unrelated perched or bedrock aquifers. Monitoring of some peripheral and mountain springs will be needed, however, to protect the Air Force from potential spurious claims of interference from the MX wells and from the unlikely event that some of the peripheral springs may be impacted by MX activities.

The closer a spring is to a pumped well, the more likely it is that pumping will affect the spring discharge. For this reason, the springs selected for monitoring generally should be those nearest an MX well or well field. However, the accessibility and discharge rate (the accuracy of the measurements increases with increased discharge) must also be considered. Springs monitored by the USGS need not be monitored by the Air Force, but copies of USGS spring flow records should be obtained for the hydrologic monitoring project data file.

5.3.2.1 Peripheral and Mountain Springs

If springs near the periphery of the valley and in the mountains occur within 5 miles (8 km) of a pumped MX well or well field, one of each type of spring should be selected for monitoring. The discharge rate of the springs should be measured monthly during the preconstruction and construction phases and semiannually (in late-spring after the major runoff has ceased and in mid- to late-fall) during the operational phase. The monitoring of these springs should be terminated when pumping of the

associated MX wells ceases. A water sample should be collected from the springs used in the discharge monitoring program before pumping begins at the associated MX wells. Periodic sampling will not be done thereafter unless some unforeseen development arises indicating a need for additional sampling.

5.3.2.2 Valley Floor Springs

In some valleys, several of the valley floor springs may have to be monitored because they are likely to be affected by pumping from MX wells. Where there are several isolated valley floor springs or a group of valley floor springs within a radius of 10 miles (16 km) of a MX well or well field, as many as three well-separated springs (with respect to the ground-water flow lines) should be monitored. One spring should be on or near the ground-water flow line leading from the well or well field and one on each side of this central flow line, where the distance between the flow line and the spring exceeds about 2 miles (3 km). A continuous recorder should be used where the discharge of a single isolated spring or the combined discharge of several springs, or of a spring area, is more than 500 gpm (32 l/s) if the water is used for such purposes as irrigation of cultivated crops, wildlife refuge, industry, public supply, etc. The recorder should be operated long enough to satisfy the conditions explained in the Section 5.3.1. All other monitored valley floor springs should be measured monthly during the preconstruction and construction phases and semiannually as stated for the peripheral and mountain springs. Monitoring of

the valley floor springs should be terminated no earlier than one year after pumping ceases at the associated MX well(s).

Water samples should be collected for chemical-quality analysis from the nearest valley floor spring downgradient from the associated MX well or well field and within a triangular-shaped area formed as follows: the well or well field is the apex of the triangle and the two sides radiate from the apex at 15° angles along each side of the central ground-water flow line; the base of the triangle is a maximum of 10 miles (16 km) downgradient from the apex. A water sample from all perennial valley floor springs should be collected and analyzed at the same time that the monitoring program begins in each valley and they should be sampled annually thereafter for as long as the associated MX wells are pumped.

5.3.3 Streams

Although the construction and operation of the MX project will probably have no significant impact on any stream in the deployment area, certain streams should be monitored. The resulting data will be necessary to protect the Air Force from potential spurious accusations and the slight possibility that the MX project will have an unexpected adverse effect. Streams being monitored by the USGS need not be monitored by the Air Force. A copy of the stream flow records collected by the USGS should be obtained for the hydrologic monitoring project data file. The only perennial streams that should be monitored are those receiving accretions from aquifers tapped by the MX wells and then

only where the springs that contribute to stream flow are not monitored. A monitoring (gauging) station on a perennial stream should be located near the lower end of each appropriate valley. The gauging station should be equipped with a continuous recorder and it will be operated using USGS methods and standards. Water samples for sediment and chemical quality should also be collected at all gauging stations using USGS methods and standards.

Flood crest stage gauges should be installed on ephemeral streams that collect runoff from MX clusters; where the aggregate area of the cluster and the contributing drainage area above the complex exceeds 10 mi^2 (26 km^2); and where there is a potential flood hazard to paved highways, other structures, and environmentally sensitive areas. The flood crest stage gauge program will be correlated with past and present similar programs of the USGS.

6.0 IMPACT MITIGATION

The Air Force will secure a water supply in the majority of MX deployment valleys through the state water appropriations process. The procedures for obtaining a water right by this process are similar for both Nevada and Utah. In both states, one of the principal factors that the State Engineer must weigh in evaluating an application is whether or not existing rights or the valleys hydrologic system will be adversely affected by the additional development of ground or surface water at the point(s) of diversion requested. Adverse effects considered include lowering of water levels, decreased spring flows, and degraded water quality. The granting of a water right to the Air Force will indicate that, in the opinion of the State Engineer, there will be no such adverse impacts.

As input to the appropriation process, the Air Force is developing computer numerical models of the valley-fill aquifer systems in all deployment valleys. These models will be used to evaluate potential points of diversion and identify those with minimum impact potential. Also, to help assure the lack of significant hydrologic impact, the Air Force should not locate their requested points of diversion within specified setback distances of any existing water right, point of water withdrawal, or significant or sensitive hydrologic feature. To assist him in his decision, the State Engineer will have at his disposal all of the above information as well as all basic hydrologic data for each valley where an Air Force appropriation

application is filed. However, because of the degree of uncertainty in all hydrologic projections, adverse effects or impacts could occur subsequent to Air Force water-supply developments which were not anticipated. The following discussion describes the general approach for impact avoidance during the period of MX construction and outlines mitigation alternatives if an MX-induced impact is identified.

6.1 IMPACT AVOIDANCE

The two major components of the Air Force program for impact avoidance are the hydrologic monitoring system and the computer numerical models of the valley-fill hydrologic systems.

The general concepts of the hydrologic monitoring program were described in Section 5.0. The principal elements of the system include monitoring of ground-water levels, spring discharges, and surface- and ground-water chemistry. Where possible, monitoring sites or stations will be located to detect hydrologic changes prior to impact occurring at existing wells or springs. All monitoring data will be collected and evaluated in a timely manner. Both will provide for early identification of significant change in hydrologic conditions and, consequently, early implementation of appropriate modifications to the MX water-supply system.

Data compiled through the hydrologic monitoring program will be used to refine the computer numerical models. The refined models will be run to verify original projections regarding long-term impacts of water withdrawal from Air Force points of

ground-water diversion. If the updated projections show impacts which were not originally anticipated, appropriate modifications to the MX water-supply system will be implemented prior to impact occurrence.

6.2 MITIGATION ALTERNATIVES

If significant or unacceptable impacts to existing water sources (wells, springs, or streams) are projected or do occur, there are several mitigation options available. These include:

- o Reduction of rate of water withdrawal at point of diversion causing impact;
- o Cessation of water withdrawal at point of diversion causing impact; and
- o Delivery of water to impacted point of diversion to compensate for temporarily reduced production capacity or water quality.

A spring or wetland which has a reduced water level, discharge, or water quality due to MX activities and which harbors threatened or endangered species is more difficult to reconcile. The declines can probably be returned to their pre-MX levels through the previously mentioned alteration of pumping patterns. However, the tolerance of endangered species to fluctuations in water levels, food sources, temperature, water quality, and other possible habitat parameters is presently undetermined. The best approach to mitigation of this impact is through a comprehensive hydrologic monitoring program, extrapolation of potential impacts, and implementation of impact avoidance measures.

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APPENDIX A

MATRIX DEVELOPMENT

APPENDIX A

MATRIX DEVELOPMENT

APPENDIX B

MAP DEVELOPMENT

APPENDIX C

IMPORTATION ALTERNATIVE

APPENDIX C (con't)

APPENDIX D

A.1.0 WATER-SUPPLY SELECTION MATRIX, DEFINITION OF CRITERIA AND ASSIGNMENT OF SCORES

A.1.1 INTRODUCTION

The water-supply selection matrix is a structured decision-making tool in which four water-supply alternatives are evaluated with respect to six selection criteria. Water-supply alternatives are ranked on the basis of final weighted scores that are the sum of individual weighted criteria scores. Individual criteria scores are based on measurable quantities common to each of the 14 valleys studied for this report. The four water-supply alternatives evaluated in this matrix are:

- Valley-fill aquifer (new water appropriations from the local flow system);
- Carbonate aquifer (new water appropriations from the regional flow system);
- Lease/purchase (existing water appropriations from any available source); and
- Importation (interbasin transfers from local flow systems).

These alternatives are described in greater detail in Section 3.0 of this report. The six selection criteria used to evaluate each alternative are:

- Legal water availability;
- Physical water availability;
- Development of related impacts;
- Cost;
- Timeliness; and
- Water quality.

The matrix format and score notation used in this appendix are shown in Table A-1.

		Valley-fill Aquifer		Carbonate Aquifer		Lease/ Purchase		Importation	
Criteria	Weight	Score	Wt. Score	Score	Wt. Score	Score	Wt. Score	Score	Wt. Score
Legal Water Availability	10	Sl, v		Sl, c		Sl, l		Sl, i	
Impacts of Development	10	Si, v		Si, c		Si, l		Si, i	
Physical Water Availability	10	Sp, v		Sp, c		Sp, l		Sp, i	
Cost	4	Sc, v		Sc, c		Sc, l		Sc, i	
Timeliness	6	St, v		St, c		St, l		St, i	
Water Quality	2	Sq, v		Sq, c		Sq, l		Sq, i	
Final Weighted Score									

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WATER SUPPLY SOURCE MATRIX
SCORE NOTATION

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TABLE A-1

The water-supply selection matrices were developed using all presently available sources of information. Definitions and score descriptions and documentation of matrix input are presented in Section A.1.1 through A.1.7 of this appendix to assist the reader in understanding and evaluating the matrix results. Each section follows a similar format that includes scoring equations and example calculations. Tables are used to incorporate as much documentation as possible into this appendix, but where this is impractical, references to other sections of this report and other reports are sited.

While the matrix is structured, many elements of the matrix involve judgments and assumptions based on an understanding of the hydrogeology of the studied valleys and obtained through a variety of water-resource investigations. Some aspects of this judgment are visable in the criteria weighting factors; others are apparent in the criteria explanations and exceptions.

The selection criteria and weighting factors were selected by considering the most critical constraints on water-supply development. Without a source of water, construction of the proposed system could not proceed, therefore, both the legal and physical availability of water were considered critical to development and weighted by a factor of 10. Futhermore, if water could be obtained but the consequence of development was a severe impact to the hydrologic system, associated biologic systems, or existing users, then development could not occur. Thus, impact was also weighted by a factor of 10.

In addition to the three most critical development factors described above, the construction considerations of time, cost, and water quality are included in the selection matrix. While these factors may greatly influence the selection of a water-supply source, there are compromises that can be made to meet the construction objectives. As long as water is available, a variety of construction alternatives can be considered. Because an objective of the MX program is to meet a perceived threat to national security that is judged to increase with time, and because delays in construction will ultimately increase the cost of construction, cost is weighted just slightly less than timeliness. While water-qualtiy considerations can influence water-source selection and must be considered, numerous construction options and widespread availability of suitable quality water are indications that water quality will not be a critical factor to MX water-supply development. Time, cost, and water quality criteria are weighted by factors of 6, 4, and 2, respectively, to reflect the concerns described above.

A.1.2 LEGAL WATER AVAILABILITY ($S_{1,x}$)

The score assigned to each alternative for the legal availability score assigned to each alternative is based upon the ratio of water available under each alternative to the peak MX water requirements. For the purpose of this report: 1) water available for new appropriations is equal to perennial yield minus existing ground-water rights, and 2) water available for lease or purchase is equal to the sum of existing water rights. The general equation used to calculate the score follows.

$$S_{1,x} = \left(\frac{V_a}{V_r} \right) \times 10 \qquad (A1)$$

Where: $S_{1,x}$ is the score for alternative x,

V_a is the volume of water available through alternative x, and

V_r is the volume of water required in the valley during the peak construction year (U.S. Army Corps of Engineers, 1981).

The value of V_r remains constant for each valley, and the values used for this calculation are presented in Table A-2. The value of V_a varies for each alternative in each valley and is calculated as described below.

A.1.2.1 Valley-Fill Aquifer ($S_{1,v}$)

$$V_a = (V_{py} - V_{gw}) \qquad (A2)$$

Where: V_{py} is the perennial yield of the valley as determined from published sources (Table A-2), and

V_{gw} is the total appropriated ground water for the valley as determined by inventories of state records by Woodburn and others (1981) and Desert Research Institute (1980) (Table A-2).

Scores for the valley-fill alternative may range from zero to 10. Where the volume of water available (V_a) exceeds the volume of water required (V_r), a score of 10 is assigned regardless of the volume of water available in excess of the requirements.

Example:

Lake Valley: $S_{1,v} = \frac{(17,000-25,333)}{2352} \times 10 = -35$

therefore $S_{1,v} = 0$

[illegible]

[illegible]	[illegible]	[illegible]	Appropriated Ground Water (Vgw)	Surface Water Use (Vsw)
[illegible]	[illegible]	[illegible]	31	1013
[illegible]	[illegible]	[illegible]	0	17
[illegible]	[illegible]	[illegible] (2)	200	-
[illegible]	[illegible]	[illegible]	16	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	21
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	370	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-
[illegible]	[illegible]	[illegible]	[illegible] (4)	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	10,692	-
[illegible]	[illegible]	[illegible]	2,710	-
[illegible]	[illegible]	[illegible]	21,912	[illegible]
[illegible]	[illegible]	[illegible]	34	[illegible]

[illegible] regional carbonate system.
[illegible] is for valley-fill only.
[illegible]

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WATER AVAILABILITY – LEGAL VARIABLES

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TABLE A-2

AD-A112 958 ERTEC WESTERN INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION. WATER RESOURCES PROGRAM. VOLUME I. PRE--ETC(U)
SEP 81 F04704-80-C-0006
UNCLASSIFIED E-TR-53-VOL-1 NL

4 OF 4

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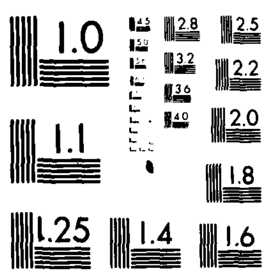
4 OF 4

AD A112958



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Dry Lake Valley $S_{1,v} = \frac{(3000-19)}{4371} \times 10 = 6.8$

therefore $S_{1,v} = 7$

A.1.2.2 <u>Carbonate Aquifer</u> ($S_{1,c}$)

The value of V_a and the score ($S_{1,c}$) assigned to the carbonate aquifer are identical to the values of V_a and the score ($S_{1,v}$) calculated for the valley-fill aquifer. The two systems are considered as a single system for the pupose of appropriations. The carbonate aquifer is scored in this conservative manner because the Nevada and Utah State Engineers have not indicated that appropriations from the carbonate aquifer will be considered as separate appropriations.

Examples: Same as those for $S_{1,v}$ above.

A.1.2.3 <u>Lease/Purchase</u> ($S_{1,l}$)

$$V_a = V_{gw} + V_{sw} \tag{A3}$$

Where: V_{gw} is the total appropriated ground water for the valley (same as valley-fill aquifer), and

V_{sw} is the total surface water use for the valley (surface-water use figures are used in this calculation because they are judged to be a more accurate indication of the actual quantity of surface water available for construction than the total of certificated surface water rights granted by the state engineers).

Scores ($S_{1,l}$) for the lease/purchase alternative may range from zero to 10 depending upon the availability of water for lease and purchase. Where the volume of water available (V_a) exceeds the volume required by MX construction (V_r), a score of 10 is assigned regardless of the volume of water available in excess of the requirements. The value of $S_{1,l}$ is only a measure of the

legal availability of water under the lease/purchase alternative and does not consider whether owners of existing water rights would choose to make them available to the Air Force.

Examples:

Lake Valley $S_{1,1} = \frac{(25{,}333 + 4583)}{2352} \times 10 = 127$

therefore $S_{1,1} = 10$

Dry Lake Valley $S_{1,1} = \frac{(19 + 21)}{4371} \times 10 = 0.1$

therefore $S_{1,1} = 0$

A.1.2.4 <u>Importation</u> ($S_{1,i}$)

$$V_a = V_{py} - V_{gw} - V_r \tag{A4}$$

Where: V_{py} is the perennial yield of the <u>source</u> valley as determined from published sources (Table A-2),

V_{gw} is the total appropriated ground water in the <u>source</u> valley as determined by inventories of state records by Woodburn and others (1981) and Desert Research Institute (1980) (Table A-2), and

V_r is the volume of water required in the <u>source</u> valley during the peak construction year.

Scores ($S_{1,i}$) for the importation alternative may range from zero to eight. Where the volume of water available (V_a) for importation exceeds the volume required in both the source (V_{gw}) valley and the receiving valley (Vr), a score of eight is assigned regardless of the volume of water available in excess of requirements. Because source valleys are defined as having a surplus of available water rights, the score ($S_{1,i}$) always has a value of eight. This upper limit is established on the assumption that Nevada and Utah State Engineers would prefer intrabasin development to interbasin transfers where sufficient water

was available within a basin. The slightly lower score reflects this concern but does not indicate the likelihood of intrabasin transfers being approved. Interstate transfers of water are not expected to receive approval and have not been suggested within this management plan.

Example:

Lake Valley (Spring Valley as source)

$$S_{1,i} = \frac{(100{,}000 - 21{,}812 - 629)}{2352} \times 10 = 330$$

therefore $S_{1,i} = 8$

A.1.3 PHYSICAL WATER AVAILABILITY ($S_{p,x}$)

The score ($S_{p,x}$) assigned to each alternative for the physical availability of water is a measure of the degree to which the nature of the alternative influences the development of a water-supply system. For the aquifer systems, development is influenced by the spacial distribution of water-bearing zones and the ability of the aquifers to yield water to wells. For surface water sources, development is strongly influenced by the need to construct diversion and transportation structures. The diverse nature of these water sources together with variations in the level of understanding of each source prevent the use of any single standard against which each alternative may be compared. The scores reflect an understanding of the problems associated with development. The following sections describe the methods used to evaluate each alternative.

A.1.3.1 Valley-Fill Aquifer ($S_{p,v}$)

Valley-fill aquifers are present beneath much of the MX deployment area, and field investigations have been made to assist in defining both the areal extent and hydraulic properties of these aquifers. The factor judged to most significantly influence development of these aquifers is well yield. Estimates of valley-fill well yields for each of the 14 study area valleys have been compiled by Ertec as part of on going water resource investigations (Table A-3). These estimates are made on the basis of: 1) reconnaissance of existing production wells, and 2) aquifer test results for Air Force test wells. The values are not maximum or minimum expected discharge estimates, but are estimates of the well yield that might be expected for a well drilled at a site that was selected with some knowledge of the valley's hydrogeologic setting. Similar yields should be obtained from MX production wells. The actual values of discharge will vary throughout each valley. Scores are calculated using the following equation.

$$S_{p,v} = (Q_e/100) \tag{A5}$$

Where: $S_{p,v}$ is the score for the valley-fill alternative,

Q_e is the estimated yield of a well drilled into the valley-fill aquifer, and

100 is a constant used to obtain a score between zero and 10.

Example:

Lake Valley: $S_{p,v} = \frac{1000}{100} = 10$

therefore $S_{p,v} = 10$

Water Availabilty - Physical

	Estimated Discharges (Qe)	Ground Water Weighting Factor (Wgw)	Surface Water Weighting Factor (Wsw)
[illegible]	250	0.03	0.97
[illegible]al	450	0	1
[illegible]yote	100	1	0
[illegible]lamar	150	0.3	0.7
[illegible]y Lake	1,000	0.48	0.52
[illegible]calante	1,000	1.0	0
[illegible]rden	450	0.66	0.34
[illegible]amlin	750	1.0	0
[illegible]ke	1,000	1	0
[illegible]leshoe	250	0.48	0.52
[illegible]hranagat(1)	1,000	–	–
[illegible]rroc	250	1	0
[illegible]ne	300	0.88	0.12
[illegible]ilroad (1)	1,000	–	–
[illegible]ake (1)	1,000	–	–
[illegible]ring	1,000	1.0	0
[illegible] Wah	700	0.40	0.60

[illegible] Source valley for importation alternatives

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WATER AVAILABILITY – PHYSICAL VARIABLES

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TABLE A-3

A.1.3.2 Carbonate Aquifer ($S_{p,c}$)

The regional carbonate aquifers are readily accessible throughout the deployment area, and the aquifer characteristics are highly variable. In many areas, the carbonate systems are absent where the bedrock is volcanic or the depth to the top of the system is excessive. Where the carbonate rocks do exist at drillable depths (less than 2000 feet [610 m]), the aquifer or water-bearing portions are most commonly associated with zones of fracturing and are limited in areal extent. Thus, the hydrologic character of the regional carbonate aquifers are quite variable and aquifer characteristics, such as transmissivity, measured in aquifer tests may be valid only in the vicinity of the test well. The physical availability of water from carbonate aquifers are best assessed in general terms by considering the factors influencing the occurrence of water in the carbonate system and ranking each valley on the basis of selected favorability criteria including presence or absence of aquifers, aquitards, and faults and position in regional flow regimes and land-use restrictions on favorable areas. Such an assessment has been performed by Ertec as part of the carbonate aquifer program. The results of this assessment are presented in Table A-4. A score for the water-supply selection matrix was obtained using the results of the matrix in Table A-4 in the following equation.

$$S_{p,c} = (R^{+}/R) \times 10 \qquad \text{(A6)}$$

Where: $S_{p,c}$ is the score for the carbonate alternative,

R is the number of rating criteria in the matrix of Table A-4 (6) plus one (1) additional criteria

RATING CRITERIA

MX VALLEYS	1	2	3	4	5	6	RATING OF DEVELOPMENT POTENTIAL	WATER DEFICIENT VALLEYS (2)
1 CAVE	+	+	+	–	+	+	HIGH	
2 COAL	+	+	+	+	+	+	HIGH	
3 COYOTE SPRING(1)	+	+	+	+	+	–	HIGH	X
4 DELAMAR	–(3)	–	–	+	+	+	MODERATE	
5 DRY LAKE	+	+	–	+	+	+	HIGH	X
6 ESCALANTE(1)	–	–	–	–	–	+	LOW	X
7 GARDEN	+	+	+	+	+	–	HIGH	
8 HAMLIN	+	+	+	+	+	+	HIGH	
9 LAKE	–	–	+	–	–	–	LOW	X
10 MULESHOE	+	+	–	+	+	+	HIGH	
11 PAHROC	+	+	–	+	+	+	HIGH	
12 PINE	+	–	–	–	–	+	LOW	X
13 SPRING	–(4)	–	+	+	+	+	HIGH	
14 WAH WAH	+	–	–	–	?	+	LOW	X

(1) Operational Base Valley
(2) Defined on the basis of perennial yield, existing appropriations, designated valley or alluvial aquifer capability vs. projected MX water requirements.
(3) Aquifers present in limted areas
(4) Low-yielding carbonate aquifers are present

(+) Favorable
(–) Unfavorable
(?) Uncertain

CRITERIA – LISTED IN ORDER OF SIGNIFICANCE

1. Presence of thick hydrostratigraphic units consisting of expected high yield aquifers either exposed at the surface or at drillable depths.
2. The absence of thick hydrostratigraphic units consisting of thick aquitards which would be expected at drillable depths.
3. The absence of, or only minor occurrences of volcanic or intrusive rocks.
4. Areas of high density faulting, especially within Devonian – middle Cambrian rocks
5. Valleys within known "Regional Flow Regimes".
6. Minimal land use restrictions on favorable drilling areas

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ESTIMATED POTENTIAL FOR CARBONATE AQUIFER DEVELOPMENT

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TABLE A–4

called risk (i.e. risk associated with drilling successful carbonate wells) that is always negative; therefore, R remains constant at a value of seven (7), and

R+ is the number of rating criteria receiving positive evaluation.

Values of the score ($S_{p,c}$) may vary from zero to 10. The potential for obtaining water from the carbonate aquifer increases with increasing values of the score.

Example:

Lake Valley $S_{p,c} = \frac{1}{7} \times 10 = 1.4$

therefore $S_{p,c} = 1$

A.1.3.3 <u>Lease/Purchase</u> ($S_{p,l}$)

The physical availability of water for the lease/purchase alternative is a function of the water availability from the sources (ground water and surface water) of the leased or purchased water. For most of the 14 valleys, the water that may be leased or purchased can be obtained from the valley-fill aquifer; therefore, the physical water availability score ($S_{p,l}$) is assigned the same value as the valley-fill alternative ($S_{p,v}$). Where surface water is leased or purchased, the following equation is used to calculate the score.

$$S_{p,l} = \left(\frac{V_{gw}}{V_{gw} + V_{sw}} \times S_{p,v}\right) + \left(\frac{V_{sw}}{V_{gw} + V_{sw}} \times k\right) \qquad \text{(A7)}$$

Where: $S_{p,l}$ is the score for the lease/purchase alternative,

V_{gw} is the total appropriated ground water for the valley as determined by inventories of state records by Woodburn and others (1981) and Desert Research Institute (1980) (Table A-2),

V_{sw} is the total surface-water use for the valley (Table A-2),

$S_{p,v}$ is the water availability physical score for the valley-fill option, and

k is a surface water score of 10 that is reduced by one point because of the difficulty involved with constructing diversion and transport structures and lowered by an additional four points because of the difficulty of relocating surface-water points of diversion to points where the water can be used conveniently (the value of k is 5).

The function of the equation stated above is to weight the value of $S_{p,l}$ for the percentage of ground water and surface water contributing to the total score. This weighting is utilized in subsequent sections of this report, and for this reason, the following weighting factors are defined here as follows.

$$W_{gw} = \frac{V_{gw}}{V_{gw} + V_{sw}} \tag{A8}$$

$$W_{sw} = \frac{V_{sw}}{V_{gw} + V_{sw}} \tag{A9}$$

Values of W_{gw} and W_{sw} are given in Table A-3.

Examples:

Lake Valley Same as valley-fill score ($S_{p,v}$) because all the water available for lease or purchase is ground water.

Dry Lake Valley $S_{p,l} = (.48 \times 10) + (.52 \times 5) = 7.4$

therefore $S_{p,l} = 7$

A.1.3.4 <u>Importation</u> ($S_{p,i}$)

Water obtained under the importation alternative is assumed to be obtained from the valley-fill aquifer of the source valley. For this reason, the physical water availability score for the

importation alternative is calculated in the same manner as the score for the valley-fill alternative (Equation A5). Q_e (Table A-3) is the estimated yield of a single well drilled into the valley-fill aquifer of the source valley.

Example:

Lake Valley $S_{p,i} = \frac{700}{100} = 7$ where Spring Valley is the source valley

therefore $S_{p,i} = 7$

A.1.4 DEVELOPMENT-RELATED IMPACTS (S_i)

The impacts of water-supply development to hydrologic and biologic systems and existing wells and springs in the 14 valleys are assessed in a manner that permits an evaluation of the relative risk of developing the four water-supply alternatives. No attempt has been made to evaluate the impacts of specific water-supply systems (i.e. combinations of wells and/or surface-water diversions) nor are the impacts assumed for each valley considered to be inevitable consequences of development. Rather, scores were obtained by considering the potential for impacting existing conditions, and where the potential for a specific impact was judged to be significant, the impact was listed. The final water-supply system can be designed to avoid or minimize most of the listed impacts.

Impact scores for aquifer (valley-fill and carbonate) and importation alternatives are obtained by reducing an initial score of 10 by appropriate deductions assigned to the potential impacts being considered. A list of these impacts and corresponding deductions is presented in Table A-5. Scores of zero

IMPACT NUMBER	DEDUCTION	IMPACT HYDROLOGIC AND BIOLOGICAL SYSTEMS
1	2	Potential decrease of discharge from regional springs and impacts to associated biologic systems.
2	1	Potential decrease of discharge from unconfirmed regional springs.
3	1	Potential decrease of discharge from local springs.
4	2	Potential for temporary dewatering (removing water from storage) of aquifer by exceeding perennial yield.
5	5	Potential impacts to surface water systems, associated biological systems, and established users due to diversion of surface water discharge (FOR LEASE/ PURCHASE ALTERNATIVE ONLY).
6	1	Impact to land from installation and maintenance of a pipeline (IMPORTATION ALTERNATIVE ONLY).
		WATER USERS
7	1	Decrease in quantity of unappropriated ground water available for appropriation to other users.
8	1	Potential for impact to local users of water for stock watering.
9	2-3	Potential for impact to local users of water for irrigation. The additional deduction of one point is made when the potential for impact is considered significant enough to result in the loss of productive agricultural acreage and induce socioeconomic impacts to agricultural communities.

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IMPACT DESCRIPTIONS
AND DEDUCTIONS

TABLE A-5

to 10 are possible; a score of zero indicates the potential for a variety of impacts and a score of 10 indicates no potential impacts. The impacts for which deductions were made to each valley score are listed in Table A-6.

Impact scores for the lease/purchase alternative are obtained by weighting scores for valley-fill and surface-water sources for the percentage of water being derived from each source. The following equation is used to obtain the lease/purchase scores ($S_{i,l}$).

$$S_{i,l} = (S^*_{i,v} \times W_{gw}) + (I_5 \times W_{sw}) \qquad \text{(A10)}$$

Where: $S_{i,l}$ is the impact score for the lease/purchase alternative,

W_{gw} is the percentage of the total water that may be available to the lease/purchase alternative that is ground water (Equation A-8),

W_{sw} is the percentage of the total water that may be available to the lease/purchase alternative that is surface water (Equation A-9).

$S^*_{i,v}$ is the development-related impact score for the valley-fill alternative that has been modified for impacts not associated with the lease/purchase alternative; (example: If development of the valley-fill alternative would have the potential for dewatering the aquifer by exceeding the perennial yield of the valley, then because the lease/purchase alternative does not involve withdrawal of additional water, the valley-fill impact score is increased by the amount of the oiginal deduction [two points] before the score is weighted in the above equation), and

I_5 is the impact score for surface-water development obtained by reducing a score of 10 by an amount of five for the reasons described under impact five in Table A-5.

Example:

Dry Lake Valley $S_{i,l} = (10 \times .48) + (5 \times .52) = 7.4$

therefore $S_{i,l} = 7$

	Alternatives (1)			
	Valley Fill	Carbonate	Lease / purchase	Importation
Cave	3, 7, 8	3, 8	5	6, 7, 9
al	7	3	5	1, 6, 7, 9
yote	1, 4	1, 3, 4, 8	-	6, 7, 9
iamar	7	3	5	6, 7, 9
Dry Lake	7	1, 3	5	6, 7, 9
Escalante	4, 9	0	9 *	3, 6, 7, 9
rden	7, 8	3, 8	5, 8, 9	1, 6, 7, 9
Hamlin	3, 7, 9	1, 9	3, 9 *	3, 6, 7, 9
ke	4, 9	1, 9	9 *	6, 7, 9
ieshoe	7	3	5	6, 7, 9
nroc	4	1	0	6, 7, 9
ne	7	3, 8	5	3, 6, 7, 9
pring	7, 9	3, 9	0	3, 8
Wah	3, 7, 8	1, 8	3, 5, 8	3, 6, 7, 9

Three (3) point deduction for impact 9
Explanation of impact numbers in table A - 5

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POTENTIAL IMPACTS OF
WATER SUPPLY ALTERNATIVES

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TABLE A-6

A.1.5 COST ($S_{c,x}$)

The score for the cost of each alternative is a measure of the relative expense to develop each source of water and is obtained by comparing estimates of the costs required to develop each alternative. Major cost components considered in the estimates are drilling of valley-fill wells, drilling of carbonate wells and construction of pipeline and pumping facilities. Combinations of these cost components are assembled as appropriate (example, importation requires drilling of valley-fill wells in the source valley and the construction of a pipeline) for each alternative for each valley, and a score for each alternative is obtained using the following equation.

$$S_{c,x} = \frac{C_{le}}{C_x} \times 10 \qquad \text{(A11)}$$

Where: $S_{c,x}$ is the score of alternative x,

C_{le} is the cost of the least expensive alternative, and

C_x is the cost of alternative x.

All cost estimates are stated in 1981 dollars and, although inflation will affect the total cost of each system, the relative costs are assumed to remain constant. Thus, inflation will not affect the ranking within the matrix.

Scores for the cost of each alternative may range from 10 to zero; an alternative rated as a 10 is the least expensive alternative, and an alternative rated as a zero is more than 20 times as expensive as the least expensive alternative.

A.1.5.1 Valley-Fill Aquifer ($S_{c,v}$)

The cost of developing the valley-fill aquifer is considered to be the cost of drilling, developing, and equipping production wells. Cost estimates for each valley are made by multiplying the number of wells required for each valley by a unit well cost. The number of wells required for each valley is assumed to be equal to the number of points of diversion at which applications for appropriations have been filed, with the exception of valleys for which either no point or one point of diversion was available. For these exceptions, the number of wells was increased as shown in Table A-7. The unit cost of a valley-fill well is calculated by designing a standard well for each valley on the basis of the average depth to water. A standard well is drilled 200 feet (61 m) into the aquifer and cased with 16-inch (41-cm) diameter casing from the surface to within 150 feet (46 m) of the bottom of the hole. The remaining 150 feet (46 m) is screened and the bottom 200 feet (61 m) is gravel-packed. The completed hole is developed, and a pump is installed close to the bottom of the hole. The information used to calculated the cost of a unit hole is shown in Table A-8.

Example:

Lake Valley valley-fill aquifer unit well calculations (500-foot [152-m] deep well)

Drilling:	500 feet @ $45 per foot	$22,500
Casing:	350 feet @ $25 per foot	8,750
Screen:	150 feet @ $50 per foot	7,500
Gravel Pack:	200 feet @ $20 per foot	4,000
Development:	24 hours @ $150 per hour	3,600
Pump Installation:	500 feet @ $10 per foot	5,000
Pump:	1 @ $30,000	30,000
Unit Well Cost		$81,350

VALLEY	# Water Appropriations	Depth (ft)	# Of Wells For Cost ~	Unit Well Cost ($)
Cave	6	500	6	81,350
Coal	9	1,100	9	237,850
Coyote	1	–	2	– (1)
Delamar	1	1,000	3	226,100
Dry Lake	1	800	3	158,600
Escalante	0	500	3	81,350
Garden	8	800	8	160,850
Hamlin	4	600	4	91,850
Lake	5	500	5	81,350
Horseshoe	3	800	3	158,600
Pahroc	4	1,000	4	211,350
Pine	5	700	5	150,350
Spring	5	600	5	91,850
Wah Wah	7	800	7	160,850

(1) No estimate calculated, carbonate wells to be utilized as discussed in section 4.3

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VALLEY–FILL ALTERNATIVE
COST ESTIMATE DATA

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TABLE A-7

DRILLING

0 to 500 feet @ $45 per foot
500 to total depth @ $70 per foot

MATERIALS (16-inch diameter well installed)

Casing _*_ feet @ $25 per foot
Screen 150 feet @ $50 per foot
Gravel pack 200 feet @ $20 per foot include bentonite seal at $20 per foot

DEVELOPMENT

24 hours @ $150 per hour

PUMP INSTALLATION

_**_ feet @ $10 per foot when setting is less than or equal to 700 feet deep

_**_ feet @ $20 per foot when setting is greater than 700 feet deep

PUMP COST

When lift is: less than 500 feet, pump cost is $ 30,000***
500 to 800 feet, pump cost is $ 70,000
800 to 1000 feet, pump cost is $110,000

---

* Total feet of casing is equal to total depth minus 150 feet of screened interval

** Pump is set to total depth

*** Local vendor information

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UNIT—WELL COSTS FOR
VALLEY-FILL AQUIFER WELLS

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TABLE A-8

5 wells x \$81,350/well = \$406,750

$$S_{c,v} = \frac{\$406,750}{\$406,750} \times 10 = 10$$

A.1.5.2 Carbonate Aquifer ($S_{c,c}$)

The cost of developing the carbonate aquifer is considered to be the cost of constructing, drilling, developing, and equipping production wells. Cost estimates for each valley are made by multiplying the number of wells required for each valley (Table A-7) by the unit cost of a well completed in the carbonate aquifer. The number of wells in each valley is assumed to equal the number of valley-fill wells described in Section A.1.5.1. This assumption is judged to be appropriate because although a single carbonate well has the potential to produce larger volumes of water than a single valley-fill well, there is no assurance that a carbonate well will actually produce a larger discharge. High-yield carbonate wells normally intersect fractured or cavernous rock in which permeability is locally very high. Carbonate wells that do not intersect these localized zones of permeability are often much less productive. Furthermore, drilling risks associated with carbonate wells are greater than those associated with valley-fill wells. Successful completion of a single carbonate well may require the expense of drilling more than one hole. The unit cost of a 16-inch (41-cm) diameter, 2500-foot (762-m) deep well is assumed to be \$460,000 on the basis of Ertec test well drilling experience.

Example:

Lake Valley

5 wells x 460,000 = 2,300,000

$$S_{c,c} = \frac{406,750}{\$2,300,000} \times 10 = 1.76$$

therefore $S_{c,c} = 2$

A.1.5.3 <u>Lease/Purchase</u> ($S_{c,l}$)

The cost of obtaining water from the lease/purchase alternative is defined as the cost of leasing or purchasing the required water plus the cost of drilling the required wells in the valley-fill aquifer. In this definition, the assumption is made that existing points of diversion (surface water) and existing wells cannot be used because they are not located or constructed appropriately. The cost of developing wells in the valley-fill aquifer is the same as was computed for the valley-fill alternative described above. The cost of lease or purchase water is the cost per acre-foot multiplied by the total number of acre-feet required by MX during the peak construction year (Table A-2). The cost of leasing or purchasing is assumed to be \$16 per acre-foot per year for the eight-year construction period or \$128 per acre-foot. The unit cost is based upon a range of prices reported by Mower (written communication, 1981). The cost of diverting any surface water component in the lease/purchase alternative is assumed to be equal to the cost of developing a similar quantity of water from the valley-fill aquifer. Costs are calculated using the following equation.

$$C_{lp} = C_{vf} + C_w \qquad \text{(A12)}$$

Where: C_{lp} is the cost of the lease/purchase alternative,

C_{vf} is the cost of developing the valley-fill aquifer as described in Section A.1.5.1, and

C_w is the cost of leasing or purchasing the peak water requirements (Table A-2) for a period of eight years at a cost of $16 per acre-foot per year

Example:

Lake Valley

$$\$406,750 + \$128\ (2352) = \$707,806$$

$$S_{c,1} = \frac{\$406,750}{\$707,806} \times 10 = 5.7$$

therefore $S_{c,1} = 6$

A.1.5.4 Importation ($S_{c,i}$)

The cost of developing the importation alternative is considered to be the cost to build a pipeline from the source valley to the receiving valley plus the cost of drilling wells required to produce the required water in the source valley. The length of the pipeline (Table A-9) is the distance measured along the DTN from a suitable source area in the source valley to a suitable receiving area in the receiving valley. Pipeline costs were estimated by designing hypothetical pipeline systems that could supply a required flow rate for a range of pipeline lengths and lifts representative of those within the area of investigation. A summary of the design results are presented in Table A-8, and a discussion of pipeline design and cost calculations is presented in Appendix C. The cost estimates include the costs of materials and construction for the pipeline and pumping station(s) but do not include the cost of energy to operate the system. The number of wells and the cost of wells needed to supply the pipeline (Table A-9) are determimed by the characteristics of the receiving valley. Th^ peak MX construction

Valley	Pipeline Variables: Length mi.	Lift ft.	Time mon.	Cost ($ x 10^6)	Well Costs: # of wells in source	Unit cost of well in source $
Cave	56	400	4	8.5	2	91,850(1)
Coal	60	1600	8	14.1	2	91,850(2)
Coyote	60	1000	4 yrs. (6)	43.2	N/A (5)	N/A (5)
Delamar	115	500	8	17.4	1	91,850(1)
Dry Lake	84	500	[illegible]	19.7	3	91,850(1)
Escalante	56	800	12	16.6	5	80,100(3)
Garden	40	600	8	6.0	1	91,850(2)
Hamlin	20	400	2	4.7	2	80,100(3)
Lake	40	300	3	9.4	2	91,850(1)
Muleshoe	55	500	3	8.3	1	91,850(1)
Pahroc	6	200	3	0.94	1	86,350(4)
Pine	40	800	4	9.4	2	80,100(3)
Spring	56	400	4	8.5	–	–
Wah Wah	60	1000	8	14.1	2	80,100(3)

(1): Source valley : Spring
(2): Source valley : Railroad
(3): Source valley : Snake
(4): Source valley : Pahranagat (interbasin transfer)
(5): Source is Colorado River, no wells required
(6): Representive of U.S. Bureau of Reclamation, personal communication, 1981.

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IMPORTATION COST AND
TIME ESTIMATES

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TABLE A-9

demand for the receiving valley is divided by estimated well yields (Table A-2) of the source valley to obtain the number of wells required. The well design is based on depth to water in the source valley. Costs are calculated by the following equation.

$$C_i = C_p + C_d \tag{A13}$$

Where: C_i is the cost of the importation alternative,

C_p is the cost of the pipeline from source to receiving valleys, and

C_d is the cost of drilling the source-valley wells required to supply the pipeline.

Example:

Lake Valley

$$179{,}200 + 9{,}400{,}000 = 9{,}579{,}200$$

$$S_{c,i} = \frac{406{,}750}{9{,}579{,}200} \times 10 = 0.42$$

therefore $S_{c,i} = 0$

Because the method of scoring the cost criteria does not resolve or differentiate alternatives costing more than 20 times the least expensive alternative, a special note is necessary for the importation alternative. The cost of constructing the pipelines required by the importation alternative is generally well in excess of 20 times more expensive than drilling valley-fill wells. Thus, the relative cost of this alternative is not adequately described by this scoring technique.

A.1.6 TIMELINESS ($S_{t,x}$)

Timeliness is a measure of the relative speed with which each water-supply alternative can be developed to supply the first

unit volume of water. Major tasks that must be considered in this evaluation are the times required to drill a valley-fill well, drill a carbonate well, and construct a pipeline. Scores for timeliness are derived from a ratio of the fastest option to each option using the following equation.

$$S_{t,x} = \frac{T_f}{T_x} \times 10 \qquad \text{(A14)}$$

Where: $S_{t,x}$ is the score of alternative x,

T_x is the time required to obtain water from alternative x, and

T_f is the time required to obtain water from the fastest alternative.

The times (T_x) required for valley-fill and carbonate development are assumed, on the basis of experience, to be 0.5 month and 2 months, respectively. The time required for development of the lease/purchase option is defined as the time to develop the valley-fill option except where a percentage of the water obtained by lease/purchase is surface water.

Example:

Dry Lake Valley $S_{t,c} = \frac{.5 \text{ month}}{2 \text{ months}} \times 10 = 2.5$

therefore $S_{t,c} = 3$

Where surface water must be considered, $S_{t,l}$ is calculated using the following equation.

$$S_{t,l} = (W_{gw} \times S_{t,v}) + (W_{sw} \times 5) \qquad \text{(A15)}$$

Where: $S_{t,l}$ is the timeliness score for the lease/purchase alternative,

W_{gw} and W_{sw} are weighting factors described by equations A8 and A9,

$S_{t,v}$ is the timeliness score for the valley-fill alternative, and

5 is surface water score of 10 reduced to five for difficulties associated with constructing surface-water diversion structures.

Example:

Dry Lake Valley

$$S_{t,1} = (.48 \times 10) + (.52 \times 5) = 7.4$$

therefore $S_{t,1} = 7$

The time required to develope the importation alternative is defined as the time necessary for construction of the required pipelines. Times were assigned based on the ranges of lengths and lifts shown below. The assigned times assume sufficient manpower is available to construct the pipeline in the given time and must be considered as minimum times to complete construction. Specific time data are presented in Table A-9.

LENGTH	LIFT (MAXIMUM)	TIME
<50 miles	400 feet	3 months
	800 feet	4 months
50-75 miles	400 feet	4 months
	800 feet	8 months
75-100 miles	400 feet	8 months
	800 feet	12 months

The scores for timeliness may range from zero to 10 where a score of 10 is the most timely alternative to construct and a score of zero is more than 20 times less timely than the most timely alternative.

A.1.7 WATER QUALITY ($S_{q,x}$)

Water quality is included in the Water Supply Selection Matrix to indicate the importance of this variable to water-supply

development. However, variations in water quality are not a limiting factor to MX water-supply development as indicated by the uniform scores received by each alternative in each valley. The only alternative not receiving a score of 10 was the Coyote Spring Valley carbonate aquifer alternative. This single exception was made because fluoride standards for drinking water are exceeded in existing carbonate wells. Because this water is from the regional system, the assumption is made that all carbonate wells in this area will exceed the fluoride standards.

Locally, the concentrations of some chemical constituents exceed state and federal guidelines for drinking water, however, suitable quality water is available at most locations in each valley.

A.2.0 ADDITIONAL DRILLING AND TESTING MATRIX, DEFINITION OF CRITERIA AND ASSIGNMENT OF SCORES

A.2.1 INTRODUCTION

The purpose of the additional drilling and testing matrix is to identify well sites that will 1) be suitable for water production, and 2) provide additional data with which to assess potential adverse impacts of MX production wells on the environment and hydrologic system. The additional information will supplement the limited data presently available, reducing the number of assumptions that must be made and increasing the confidence level in water management decisions. With this rationale in mind, the additional drilling and testing matrix was developed to assist in evaluating 1) points of diversion for which water appropriations applications have been filed with the Nevada and Utah State Engineers and 2) selected additional test sites. This evaluation is accomplished by ranking each potential well site on the basis of the following criteria:

- o Yield potential;
- o Proximity to construction camp and batch plant;
- o Proximity to clusters and DTN; and
- o Sparseness of existing hydrogeologic data.

The first three criteria listed above describe the usefulness of a potential well site for production; the remaining criterion evaluates the need for additional data. The methods by which scores for each criteria are assigned to each potential well site are described in the following sections.

A.2.2 YIELD POTENTIAL

Because additional test wells will also be considered as water-supply wells, the yield of a potential well is an important consideration in the selection of additional test well sites. The yield at a potential test well site is estimated from existing hydrogeologic data to assist in ranking the site. An initial estimate of yield is obtained by using the yield values (Qe) presented in Table A-3. This initial value is then modified on the basis of geologic (presence or absence of impermeable materials) and hydrologic (aquifer characeristics estimates of saturated thickness, etc.) data to be more representative of the specific site being evaluated. A score is calculated using the following equation:

$$Sy,x = Qe^*/100 \tag{A16}$$

Where: Sy,x is the score for the yield potential criteria at site x,

Qe* is the well yield estimate shown in Table A.3 adjusted as described above, and

100 is a constant scaler used to obtain a score with a value of one to 10.

The values of Sy,x reported in the matrices range from one to 10 indicating that yield estimates ranging from 100 to 1000 gpm (6 to 63 l/s) were obtained at the evaluated sites.

A.2.3 PROXIMITY TO CONSTRUCTION CAMP AND BATCH PLANT SITES

Well sites in the vicinity of construction camps and batch plants are primary candidates for additional drilling and testing because the wells could be used as water-supply wells during construction. Therefore, potential well sites are scored

for their proximity to these facilities. Scores for proximity to construction camp and plant sites are assigned by measuring the distance between the potential well site and a potential camp or plant site. The locations of the potential plants and camps are listed below. The plant or camp is considered to be located within a 2-mile (3-km) radius of the point indicated because exact locations have not been selected.

VALLEY	CAMP	PLANT
Coal	2N-59E-15da	None
Dry Lake	4N-64E-31ac	3S-64E-28dc
Lake	7N-65E-1bc	Same
Pine	(C-27-19)9bc	None
Wah Wah	(C-26-14)26ba	Same

The distance between each potential well site and a plant or camp is defined as the distance, measured along existing roads, between the well site and the edge of the 2-mile (3-km) radius circle. A score with a value of one to 10 is assigned that is inversely porportional to the measured distance. A potential well site 1 mile (1.6 km) or less from a plant or camp receives a score of 10. The score is reduced by one point for each additional 1-mile (1.6-km) increment. Any well site greater than 10 miles (16 km) from a plant or camp is given a score of zero.

A.2.4 PROXIMITY TO CLUSTERS AND DTN

The deployment area, or area in which of shelters and associated transportation networks will be constructed, will require water for such uses as dust control and revegetation. Thus, well-site proximity to shelters and DTN is an important consideration in selecting additional drill sites. Proximity of potential well

sites to these facilities is determined by counting the number of shelters and measuring the length, in miles, of DTN that are located within areas defined by circles of 1-, 3-, and 5-mile radii (1.6-, 5-, and 8-km) centered on the well site. A score for proximity is obtained using the following equation:

$$S_{c,x} = \frac{((n_1)3 + (n_2)2 + (n_3)\,1) + (m_1)3 + (m_2)2 + (m_3)1)}{10} \quad \text{(A17)}$$

where: $S_{c,x}$ is the cluster and DTN proximity score for site x, and

n_a is the number of clusters within the following areas:

1. within a 1-mile (1.6-km) radius of the well site,
2. within the area between circles of 1- and 3-mile (1.6- and 5-km) radii, and
3. within the area between circles of 3- and 5-mile (5- and 8-km) radii.

m_a is the miles of DTN within areas 1 through 3 described above.

Shelter counts and DTN measurements for areas 1, 2, and 3 (described above) are weighted by factors of 3, 2, and 1, respectively, to give appropriate weight to shelters and DTN in close proximity to the potential well site.

Scores reported for well sites in the 14 valleys studied range from 3 to 9. The highest scores are for well sites centrally located with respect to both cluster and the DTN while the lowest scores are for well sites located near the margins of the clusters. The required measurements (number of shelters, miles of DTN, etc.) were obtained from 1:62,500 scale shelter layout maps prepared by Ertec Western, Inc. and dated 15 May 1981.

A.2.5 SPARSE DATA AREAS

One purpose of the additional drilling and testing matrix is to identify sites at which additional aquifer characterization data are needed. The sparsity of available data is determined by inspection of the area in the vicinity of each potential well site for the number and type of existing wells present and evaluating the extent to which the data from these wells are useful for characterizing the valley-fill aquifer. Three classes of wells are recognized: Air Force test wells, irrigation and domestic wells, and stock wells. In general, wells in each of these classes provide data of varying types and quality. For example, while a stock well may be useful in determining the water level in a given area, little other datum is generally available. Conversely, an Air Force test well is a source of a wide variety of geologic and hydrologic data. Domestic and irrigation wells are commonly of intermediate value. The data associated with wells are site-specific and decrease in reliability with increasing distance from a well and distance between wells. Table A-10 was developed to assist in scoring potential drill sites for sparseness of data. The table yields a maximum sparsity score for each class of well in the four distance categories.

A score is obtained by the following method. The well closest to the potential well site is located and both the distance and well class are determined. A maximum score is then obtained using Table A-10. If there are no other wells at approximately the same distance from the potential well site, then the maximum

WELL CLASS

DISTANCE (MILES)	STOCK	DOMESTIC/ IRRIGATION	AIR FORCE
<1	3	0	0
1–3	6	4	2
3–5	10	8	6
>5	10	10	10

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SCORING TABLE FOR OBTAINING MAXIMUM SINGLE-WELL SCORES

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TABLE A-10

score is the score from the matrix. However, when other wells of the same or different class are present in the valley, the maximum score may be reduced to reflect these additional sources of information.

Sparse data scores of zero to 10 are reported in the matrices for the 14 valleys in this study. High scores are an indication that very few data are available for the valley; low scores indicate the presence of one or more domestic, irrigation, or Air Force test wells near the potential well site. Required measurements (number and type of wells) were obtained from unpublished, Ertec potentiometric maps for each valley.

APPENDIX B

MAP DEVELOPMENT

B.1.0 PREFERRED AREA MAPS

B.1.1 INTRODUCTION

The preferred area maps included as Drawings 4-1 through 4-13 of this report are intended to illustrate areas within each of the 14 valleys that are suitable for obtaining water supplies from the valley-fill aquifer for MX construction and operation requirements. The main feature of the maps is suitable area that is defined as the area in which conditions are most favorable for obtaining water supplies. The data required to compile the maps were derived from a wide variety of sources that are listed on each valley map. The process used to compile the maps is described in the following sections. The data and process used to compile the Coyote Spring Valley map (see Section B.1.5) are *significantly different* from those used on the other 13 maps.

B.1.2 DEFINING PREFERRED DRILLING AREAS

Hydrogeologic characteristics of the valley-fill aquifers vary significantly in the individual valleys described in this report. The primary, secondary, and excluded (hydrologic) areas shown in Drawing 4-1 through 4-13 are classifications of the potential for obtaining a water supply. They are defined as:

- Primary: Areas in which a minimum of 200 feet (61 m) of permeable saturated valley fill is present,
- Secondary (limited saturated thickness): Areas in which 1 to 200 feet (0.3 to 61 m) of permeable saturated valley fill is present,
- Secondary (lucustrine): Areas in which a minimum of 200 feet (61 m) of saturated thickness is present but surficial geologic maps indicate the presence of low permeability lake or playa deposits, and

- o Excluded (hydrologic): Areas 1 mile (1.6 km) or less from the rock/ valley-fill boundary and/or having no saturated valley fill.

In general, water supplies should be available from both the primary and secondary areas. Primary area is considered to have the best potential to provide water. Hydrologic limitations may reduce well yield from secondary areas. Where wells must be drilled in secondary areas, the wells should be appropriately designed and the well site selected carefully to minimize the effects of the limitations.

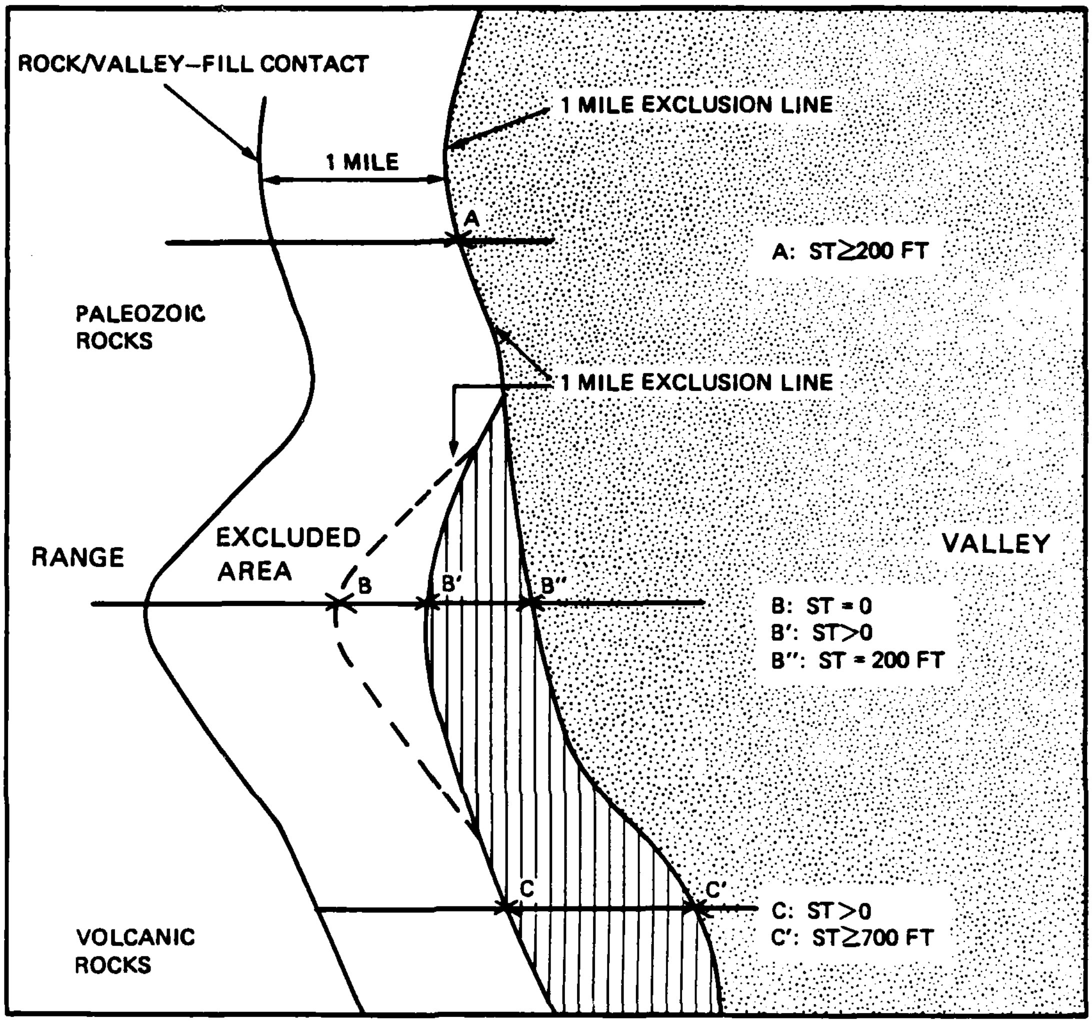
The preferred area maps were compiled as described below. The following discussion also details the assumptions made in compiling these maps. All compilation was done at a scale of 1:62,500.

1. The rock/valley-fill line (Figure B-1) was transferred from Ertec geologic maps or from other sources as indicated on each map. This line is the contact between valley-fill deposits and the rocks exposed in the adjacent range, including Tertiary volcanics. The rock/valley-fill line was originally obtained by inspection of aerial photographs and field checked under the Verification program.

2. An exclusion zone was constructed extending 1 mile (1.6 km) valley-ward from the rock/valley-fill line (Figure B-1). This zone is generally considered to be nonproductive for the reasons described in Section 3.2.2. Given the risks associated with obtaining water within 1 mile (1.6 km) of the rock/valley-fill line, this area was designated as excluded.

3. The area remaing after application of the 1-mile (1.6-km) exclusion criteria was modified on the basis of variations in the thickness of valley-fill deposits. Modifications were made to assure that sufficient saturated thickness existed within the primary areas for high-yield production wells and were made in the following manner.

   At selected points along the 1-mile (1.6-km) exclusion line, saturated thickness to valley-fill deposits was estimated by



ST = SATURATED THICKNESS

SECONDARY (LIMITED SATURATED THICKNESS) AREA

PRIMARY OR SECONDARY (LACUSTRINE) AREAS

SATURATED THICKNESS CHECK POINT

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DELINEATION OF EXCLUSION AND LIMITED SATURATED THICKNESS AREAS

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FIGURE 8-1

subtracting depth-to-water estimates (obtained from unpublished Air Force potentiometric maps) from estimates of valley-fill thickness (obtained from unpublished Air Force depth-to-bedrock interpretations of gravity data). Depending on the estimated value of saturated thickness, the exclusion line was either left in place or moved valley-ward as depicted in Figure B-1 and described below.

Where the estimated saturated thickness was greater than or equal to 200 feet (61 m), the position of the 1-mile (1.6-km) exclusion line remained unchanged (point A, Figure B-1) and a new point (point B) was selected for checking. If, at this point the thickness of saturated fill was zero (i.e., no water was present in the valley-fill deposits), then additional checks were made to locate the point (point B') at which saturated deposits existed. The 1-mile (1.6-km) exclusion line was modified to pass through point B', thereby excluding additional area.

Additional checks were made valley-ward of point B' to locate the point past which saturated thickness exceeds 200 feet (61 m), or point B", in Figure B-1. A second line drawn through point B" separates secondary (limited saturated thickness) areas from areas having greater than 200 feet (61 m) of saturated valley-fill deposits. This procedure is modified slightly along segments of the valley perimeter where significant exposures of Tertiary volcanic rock are present in the adjacent range. In these areas, 700 feet (213 m) of saturated "valley-fill" are included within the secondary (limited saturated thickness) areas to allow for the presence of up to 500 feet (152 m) of potentially nonproductive volcanic rocks beneath or within the more productive alluvial deposits. The result of using the 700 feet (213 m) saturated thickness criteria is a wider than normal secondary (limited saturated thickness) area but not an increase in excluded area (points C and C'; Figure B-1).

Volcanic rocks of the study area are less permeable than the valley-fill deposits and must be differentiated from valley fill. However, despite the differences in both origin and hydrologic properties of these materials, quantifying the relative thickness of each type in any given area is not possible on the basis of the available gravity results and interpretations. The density contrast between the volcanic rocks and valley-fill deposits is small ($\pm$ 0.1 gm/cc) relative to the contrast between either of these units and the older rocks of the adjacent ranges (+0.5 gm/cc) with which both units come in contact. Therefore, more complex gravity models than the single density contrast model used to date and more complete well control are required before differentiation of the Tertiary volcanic rocks and valley-fill deposits can be attempted. Furthermore, given the topographically complex surface on which the volcanics were deposited and the complexity of subsequent faulting, detailed modeling could only be done in a meaningful manner

for relatively small areas. Thus, in order to allow for the presence of volcanic rock, a thickness of up to 500 feet (152 m) of volcanic rock is assumed to be present on top of the bedrock surface when determining the saturated thickness of valley-fill deposits in areas adjacent to exposed Tertiary volcanic rocks.

Depth-to-bedrock estimates interpreted from gravity surveys were not available for all valleys and the quality of existing data varied from valley to valley. The list shown in Table B-1 indicates the data available for each valley. Where gravity surveys and interpretations are not present, no estimate of saturated thickness could be made, and hydrologic exclusions were limited to the 1-mile (1.6-km) exclusion and secondary (lucustrine) exclusion.

4. A map showing the areas defined in items 1 through 3 above, is further modified to reflect the distribution of relatively impermeable valley-fill deposits by using the surficial geology maps compiled by Ertec for geologic studies of 12 of the 14 valleys being investigated. Within the remaining suitable areas, lucustrine and playa deposits are outlined and an additional area of 0.5 mile (0.8 km) from these deposits is designated as secondary (lucustrine). Because only the surface distribution of these materials is known, little can be said about the vertical distribution of permeability. There is a possibility that more permeable materials exist at depth and that water supplies could be developed in the secondary (lucustrine) areas. A surficial geologic map is not available for the Escalante Desert map, and for this reason, no secondary (lucustrine) areas have been defined. A similar situation exists for Coyote Spring Valley. However, as described in Section B.1.5, this parameter is not important to water-supply development in Coyote Spring Valley.

B.1.3 AVOIDANCE OF EXISTING WATER APPROPRIATIONS

The hydrogeologically acceptable areas defined in Section B.1.2 must be further reduced to avoid conflicts with existing water appropriations. The appropriations that must be avoided are surface rights (springs and streams) and underground rights (wells). The method used to avoid these rights was to 1) identify the location of the point of diversion for each approved water right in the valley, and 2) outline an appropriate standoff radius for each type of appropriation.

	Grid	Profiles	None
Cave			x
Coal		x	
Coyote			x
Delamar	x		
Dry Lake	x		
Escalante			x
Garden		x	
Hamlin		x	
Lake	x		
Muleshoe			x
Pahroc	x		
Pine	x		
Spring	x		
Wah Wah	x		

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TYPES OF AVAILABLE
GRAVITY SURVEYS

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TABLE B-1

The locations of water rights were obtained from inventories of Utah and Nevada state water right records conducted by Desert Research Institute (1980) and Woodburn and others (1981). These points of diversion were plotted on 1:62,500 scale maps at the locations reported in these inventories. Supplementing this information are well and spring locations shown on Ertec potentiometric maps and springs from the U.S. Geological Survey topographic maps for which no water right is listed. These additional locations were assumed to have associated water rights if no indication of abandonment was available. This conservative approach was taken to minimize the risk of infringing upon water rights not identified by the inventories of state files.

The diversion points described above were plotted on the maps and, using a specified stand-off distance as the radius, a circle was drawn around the point of diversion. The area within the circle was excluded to minimize adverse impacts on existing users from MX production wells. The stand-off distances are as follows:

SOURCE	STAND-OFF DISTANCE (in miles)
Well	1
Spring	1
Regional Spring	3
Stream	0.25
Reservoir	0.25

These distances meet or exceed the distances required by the Utah and Nevada State Engineers.

B.1.4 CULTURAL EXCLUSIONS

In an effort to minimize impacts of MX production wells on nonfederal lands and environmentally sensitive areas, certain areas were excluded from consideration as potential well sites including:

Private land;

State lands and parks;

State and federal game reserves and wildlife refuges;

National parks, forests, ranges, and historical monuments;

Environmentally sensitive areas (endangered wildlife and rare plants);

Wilderness study areas;

Native American Reservations;

Desert Land Entry applications;

Patented mining claims;

Fee land;

Corps of Engineers (Code 1 exclusions); and

Known geothermal resource areas (Escalante Desert only)

With the exception of 0.5 mile (0.8 km) stand-off distance used for environmentally sensitive areas, no stand-off distances were applied to these exclusions.

B.1.5 COYOTE SPRING VALLEY MAP

There is virtually no water available from the valley-fill deposits in Coyote Spring Valley. It is presently assumed that MX production wells will tap the carbonate aquifer (Section 4.3). For this reason, the preferred area map differs significantly from the other 13 valleys studied. Only data pertaining to the

carbonate system are portrayed on the preferred area map (Drawing 4-3) including:

- o Distribution of aquifers and aquitards of the carbonate system;
- o Distribution of low yielding volcanic rock; and
- o Distribution of faulting.

Taken together, these data can be used to select locations at which carbonate aquifers are highly fractured and have a high potential for producing significant volumes of water. Because of the site-specific nature of these well locations, preferred areas have not been identified on the Coyote Spring Valley map (Drawing 4-3).

APPENDIX C

IMPORTATION ALTERNATIVE

C.1.0 IMPORTATION SOURCE VALLEYS

Importation, as described in Section 3.5 of this report, is the interbasin transfer of water from hydrographic basins in which large volumes of water are available for appropriation to basins where available water is limited. A literature review combined with hydrologic field reconnaissance and aquifer testing, as part of the Air Force Water Resources Program, indicates that there are ground-water basins which could have the potential for supplying water to other basins where available supplies are insufficient for MX needs or significant impacts to existing water users are projected. Examples are Railroad, Spring, and Snake valleys.

Railroad Valley, in the west-central portion of the siting area, has an estimated perennial yield of 75,000 acre-feet (92.48 hm^3) (Van Denburgh and Rush, 1974). Ground water in storage in the upper 100 feet (30 m) of saturated valley-fill is 8.1 million acre-feet (9987.30 hm^3) (State of Nevada, 1971) and current ground-water diversion is 4206 acre-ft/yr (5.19 hm^3/yr) (Desert Research Institute, 1980), leaving potential additional ground-water diversions within the limits of the estimated perennial yield totaling 70,794 acre-ft/yr (87.29 hm^3/yr). Certificated and permitted ground-water rights total 10,592 acre-ft/yr (13.06 hm^3/yr) (Woodburn and others, 1981). If these rights were developed to their fullest, ground-water rights available would total 64,408 acre-ft/yr (79.42 hm^3/yr).

Spring Valley, in the east-central portion of the Nevada-Utah siting area, has an estimated perennial yield of 100,000 acre-feet (123.30 hm^3) (State of Nevada, 1971). Ground-water storage in the upper 100 feet (30 m) of saturated valley fill is 4.2 million acre-feet (5178.60 hm^3) (State of Nevada, 1971) and current ground-water diversions total 4781 acre-ft/yr (5.89 hm^3/yr) (Desert Research Institute, 1980), leaving 95,219 acre-ft/yr (117.41 hm^3/yr) of potential additional ground-water diversions within the limits of the estimated perennial yield. Certificated and permitted ground-water rights total 21,812 acre-ft/yr (26.89 hm^3/yr) (Woodburn and others, 1981). If these rights are developed to their fullest, available ground-water rights would be 78,188 acre-ft/yr (96.41 hm^3/yr).

Snake Valley, which straddles the Nevada-Utah border in the northeastern portion of the siting area, has an estimated perennial yield of 49,000 acre-feet (60.42 hm^3) (State of Nevada, 1971). Ground water in storage in the upper 100 feet (30 m) of saturated valley fill totals 12.0 million acre-feet (14,796.0 hm^3) (Price, 1979). Current ground-water diversions total 15,756 acre-ft/yr (19.43 hm^3/yr) (Desert Research Institute, 1980; and Utah Water Research Laboratory, 1980), leaving 33,244 acre-ft/yr (40.99 hm^3/yr) of potential additional ground-water diversions within the limits of the estimated perennial yield. The total certificated and permitted water rights for Snake Valley have not yet been determined.

In specific cases, such as a source of water to import to Coyote Spring Valley and Pahroc Valley, the Colorado River and

Pahranagat Valley are considerations. There are a significant number of pending applications for appropriation of ground water in Pahranagat Valley, however, and the disposition of these applications following assessment by the State Engineer could affect the viability of this valley as a source of water supply.

Imported water for Coyote Spring Valley may be obtained from the Colorado River. The State of Nevada currently has a Colorado River allotment of 300,000 acre-ft/yr (369.90 hm^3/yr) (Holburt, 1981). Rights to the majority of the Colorado River allocation in Nevada are held by the Las Vegas Valley Water District. Nevada is currently diverting only about 150,000 acre-ft/yr (184.95 hm^3/yr) according to a representative of the Division of Colorado River Resources for the State of Nevada. This indicates that the Las Vegas Valley Water District has a large quantity of unused water that could be made available for MX use. The current policy of the district, however, is that its long-term water use must be for municipal and industrial purposes, and its use is restricted to Clark County, Nevada. Short-term use for agriculture or construction may be possible following a detailed study and review by district authorities. Legislative changes would be required for use outside Clark County. The OB, as presently sited, lies almost wholly within Clark County.

C.2.0 ASSUMED DESIGN PARAMETERS FOR CONVEYANCE

C.2.1 SITE-SPECIFIC PARAMETERS

As part of the process for selecting the source of construction water for each valley, it was necessary to make preliminary estimates of the cost of conveying water from a source in one valley to an MX construction site in another valley. The cost estimates require site-specific parameters such as flow rate, distance, and change in elevation, and these parameters vary with each comination of water source and construction site. It was beyond the scope of this report to perform even a preliminary cost estimate for each specific combination. Instead, the many combinations of flow, distance, and elevation difference were collected into similar groups, and a typical case was used to represent each group.

The site specific parameters assumed for each of the typical cases are rate of flow in gallons per minute (gpm), length of pipeline in miles, static lift in feet, and the difference in elevation between the beginning and end of the pipeline. For any site or typical case, the rate of flow is the average for the year in which the amount of water for construction is the greatest. In order to provide access to the pipeline without construction of special roads, the length of pipeline is the distance following roads that either presently exist or will be constructed as part of MX development. The static lift, often called static discharge head or static head, is the difference between the elevation at the start of the pipeline and the

maximum elevation at the ridge over which the water must pass on its way to the construction site. The static lift is not necessarily equal to the difference between the elevations at the beginning and end of the pipeline. Table C-1 shows the value of parameters assumed and the range of values for which the typical case is applicable. A few of the valleys are special cases for which only one value of a parameter was considered. No ranges are shown for these cases.

For many valleys, the pipeline lengths fall in the range of 30 to 60 miles (48 to 97 km) or in the range of 70 to 120 miles (113 to 193 km). Each of these ranges was treated as a typical case with representative lengths of 50 and 100 miles (80 to 161 km), respectively.

Many valleys have static lifts that can be represented by 500 or 900 feet (152 or 274 m), and each of these values was used as a typical life. The ranges of lifts for which these cases are applicable was detemined by the length and size of the pipeline.

The required flow rates range from 200 to 6000 gpm (13 to 379 l/s). It was not feasible to consider more than a few values. Those flows less than 1500 gpm (95 l/s) were treated as a case represented by 1500 gpm (95 l/s), while those between 1500 and 3000 gpm (95 and 189 l/s) were treated as a case represented by 3000 gpm (189 l/s). A flow of 6000 gpm (379 l/s) was treated as a special case.

CASE	PEAK FLOW gpm	PIPELINE LENTH		STATIC LIFT	
		LENGTH / miles	RANGE miles	LIFT feet	RANGE feet
1	1500	6	-	210	-
2	less than 1500	50	30-60	500	200 to 800
3	less than 1500	100	70-120	900	300 to 1500
4	1500 to 3000	50	30-60	500	200 to 800
5	1500 to 3000	100	70-120	900	300 to 1500
6	6000	60	-	1000	-
7	6000	155	-	500	-

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SITE-SPECIFIC DESIGN PARAMETERS
FOR TYPICAL CASES

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TABLE C-1

C.2.2 GENERAL PARAMETERS

In addition to site-specific parameters, it was necessary to assume general design parameters. The assumptions depend upon whether the conveyance system is assumed to be temporary or permanent. Temporary conveyance is suitable for those valleys in which the water requirements after MX construction are small and can be met by local sources. The conveyance can be removed after MX constuction. For OBs, the water requirements after MX construction are significant and will probably be met by the conveyance system that provides the water for construction. Thus, the conveyance for Coyote Spring Valley should be permanent.

For temporary conveyance, the following design parameters were assumed.

- o The pipeline is constructed of thin gauge steel pipe (sometimes called "invasion pipe" or "gauge pipe") with mechanical couplings,
- o The pipeline is above ground and is held in place by pipe anchors,
- o The pipe has no insulation or cover material other than a standard coating applied to resist corrosion,
- o Pump stations are temporary booster units of the type used for irrigation and consist of centrifugal pump, diesel engine, and fuel tank assembled and mounted on skids,
- o The pipe line has surge control valves and equipment rather than surge tanks, and
- o Pump stations do not have standby capacity.

For permanent conveyance, it was necessary to assume the following general design parameters.

- o The pipeline is constructed of cement-lined iron pipe,

- The pipeline is buried in a trench,
- The pipe has no insulation or cover material other than a standard coating applied to resist corrosion,
- Each pump station on a pipeline is enclosed and has both a pump pit and a wet well to receive water from the well pumps,
- Pumps are driven by electric motors,
- The pump efficiency is 85 percent, and the combined efficiency of pump and motor is 70 percent,
- Each pump station has a surge tank or surge control equipment, and
- Each pump station has standby capacity equal to the capacity of the largest unit in the station.

C.3.0 TEMPORARY PIPELINES

C.3.1 PIPELINE DIAMETER

Because of the limited scope and preliminary nature of the cost estimates, it was not possible to select the diameter of a pipeline by the normal method of minimum total cost. In that method, the selected diameter is the one that produces the lowest present or annual value of the sum of the capital cost of pipeline and pump station plus the cost of energy, operation, and maintenance. For this study, in contrast, two or three diameters were selected for each case on the basis of practical criterion for reasonable design and judgment about reasonable cost. Later, one of these was selected on the basis of the capital cost alone.

After some preliminary calculations, it was apparent that the capital cost of temporary conveyance is dominated by pipe diameter. It does not pay to increase the diameter of the pipe in order to reduce the capacity or number of pump stations. This result stems in part from the great length of pipeline required for each valley and in part from the omission of operation, maintenance, and energy costs from consideration at this stage of the study.

These calculations and comparisons lead to one pipe diameter for each flow rate: 12 inches (30 cm) for 1500 gpm (95 l/s), 16 inches (41 cm) for 3000 gpm (189 l/s), and 18 inches (46 cm) for 6000 gpm (379 l/s). The pipe length and static lift did not affect the selection of diameter.

C.3.2 PUMP STATION CAPACITY

The temporary pump station considered for the temporary pipelines are available for various capacities (flow rates), but the total delivered head is equivalent to about 75 pounds per square inch (psi) for all capacities. The capacity determines the cost. For each typical case, the capacity of each station was selected for the flow rate in the pipeline. The number of pump stations was the total head required for the pipeline in psi divided by 75.

C.3.3 SCOPE OF COST ESTIMATES

The cost estimates cover the capital costs of pipelines and pump stations with some allowance for appurtenances. No consideration is given to the cost of energy for pumping or to other operation and maintenance costs. All estimates are for mid-1981. There is no cost escalation or discounting to present value to allow for the time until construction actually begins.

C.3.4 CONSTRUCTION COST INDEX

Cost data from different sources and for different times and locations were adjusted to mid-1981 for desert valleys in Utah and Nevada by means of the Engineering News Record Construction Cost Index (ENR Index). The national average value of this index for 1981 is 3561 (ENR 1981). For water utility construction, the cost in plateau states like Nevada and Utah is somewhat less than the national average (ENR, 1981), but the comparison is usually based on costs in urban centers. For desert valleys in Utah and Nevada, it was assumed that the cost would

be about 20 percent higher than the national average. Therefore, an index value of 4250 was assumed.

C.3.5 PIPELINE COSTS

The cost of thin-walled, gauge or invasion steel pipe in mid-1981 was obtained from vendors in southern California. The cost of leasing such pipe was also discussed with these vendors, but the number of firms interested in leasing pipe is limited. When pipe is leased, the annual lease cost tends to be about 25 percent of the purchase price. If a conveyance is in place for more than four years, purchase is less expensive. The purchase price in southern California was converted to desert valleys in Nevada and Utah by means of the ENR Index.

For installation costs, it was assumed that the cost to install the pipe above ground with anchors was equal to or somewhat less than the cost to install it in trenches. The cost to install pipe in trenches was obtained from the 1980 Dodge Guide for Heavy Construction (Dodge Guide, 1979). The costs included labor and equipment for installation but did not include excavation, backfill, or contractor's overhead and profit. To this cost was added 20 percent for the cost of anchors, thrust blocks, and appurtenances and 10 percent for contractor's overhead and profit. An additional element of contractor's overhead had already been considered in the adjustment of the ENR Index for desert valleys.

The costs in the Dodge Guide were for mid-1980 when the national average ENR Index was 3198. To adjust the costs to the MX

construction area in mid-1981, the costs were multiplied by the ratio 4250/3198.

The result of the adjustment was an estimate of the construction cost. To convert it to a full capital cost, 35 percent was added for engineering, administration, and contingency.

C.3.6 PUMP STATION COSTS

Information on pump station costs was obtained from southern California vendors who provide such equipment for irrigation systems with movable pipelines. The costs were adjusted to desert valleys in Utah and Nevada by means of the ENR Index. The purchase price was increased by 100 percent to allow for delivery and installation. To this sum was added 10 percent for contractor's overhead and profit and 35 percent for engineering, administration, and contingency.

C.3.7 CONVEYANCE SYSTEM COST

For each of the flow rates, the cost of pipeline and pump stations was added to obtain a cost of conveyance system per mile. To convert the pump station costs to cost per mile, the distance between stations was established for each flow rate. The resulting costs per mile are shown in Table C-2.

C.3.8 COORDINATION OF CONSTRUCTION SCHEDULE

For any of the cases in Table C-1, the construction of the conveyance system can be scheduled to avoid delays in the construction of MX facilities. There are two approaches to avoid delays 1) to start construction of conveyance prior to construction of the other facilities or 2) to construct the conveyance

FLOW RATE gpm	COST PER MILE $
1500	151,000
3000	235,000
6000	296,000

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ESTIMATED CAPITAL COST
OF TEMPORARY CONVEYANCE

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TABLE C-2

system in a short time frame with many crews working simultaneously at different points along the pipeline.

The productivity of pipe installation crews was obtained from the Dodge Guide (1980). For the 12- to 18-inch (30- to 46-cm) diameters selected for the systems, a crew of five can be expected to lay between 190 and 320 feet (58 and 98 m) per day. Thus a crew will install between 0.8 and 1.3 miles (1 and 2 km) per month. For each crew of five, an additional crew of one or two will be needed to construct supports, move rocks, make other preparations, and install the pump stations.

To construct a 50-mile (15-km) pipeline in three months will require 65 to 105 people installing pipe and 15 to 20 people preparing the pipeline location. It will also require a considerable number of support personnel to deliver pipe and supplies at the rates needed to do the work at locations along the pipeline route.

C.4.0 PERMANENT PIPELINE FOR OPERATIONAL BASE

Case 6 is a permanent pipeline supplying Coyote Spring Valley for an OB. It was assumed that the flow rate will be 6000 gpm (379 l/s) for five years of construction and 3000 gpm (189 l/s) for 25 years of operation. The length and lift are 60 miles (97 km) and 1000 ft (305 m), respectively. Because it is a site specific case with no ranges of parameters to consider, more attention was given to selecting the pipe diameter according to minimum cost.

To find the minimum cost, several feasible pipe diameters were selected. For each diameter, the total capital cost of pipeline, pump stations, and surge tanks was estimated. The corresponding annual energy costs were estimated and converted to present worth at the beginning of construction. Several interest rates were evaluated. This present worth was added to the capital cost to obtain a total cost of capital plus energy. The minimum total cost was found to correspond to a pipe diameter of 24 inches (61 cm).

A combination of cost sources was used for this analyses. The unit cost of the completed pipeline buried in a trench was obtained from the Dodge Guide (1980) and converted to the construction site in mid-1981 by means of the ENR Index as described in Section C.3. The cost of pump stations and parts of the surge tanks were obtained from cost curves developed for planning water and wastewater facilities in southern California in 1979 and 1980. The costs were converted to the construction

site in mid-1981 by means of the ENR Index. The cost of energy was obtained from the Nevada Power Company. Contractor's overhead and profit (10 percent) and additional costs for engineering, administration, and contingency (35 percent) were added to the construction costs.

Although energy costs were considered in selecting the 24-inches (61-cm) pipeline, only the capital cost of the line was used for comparison with the cost of other water-supply alternatives for Coyote Spring Valley. The capital cost corresponding to the minimum total cost was $43 million. The estimated present value of energy cost at 12 percent interest is $6 million.

APPENDIX D

GLOSSARY OF TERMS

APPENDIX D
GLOSSARY OF TERMS

AQUIFER - A body of rock that contains sufficient saturated, permeable material to yield significant quantities of ground water to wells and springs.

Confined Aquifer - An aquifer bounded above and below by impermeable bed(s) of distinctly lower permeability than that of the aquifer itself.

Deep Aquifer - A consolidated rock aquifer, or carbonate aquifer when contained in limestone or dolomite rock, which occurs beneath the unconsolidated valley-fill sediments and in the mountain ranges. This aquifer is the conduit for any interbasin or regional-flow systems which exist. Flow is believed to be primarily through fracture and solution openings rather than intergranular.

Perched Aquifer - An aquifer separated from an underlying main body of ground water by an unsaturated zone.

Intermediate Aquifer - An intermediate aquifer is arbitrarily defined as an aquifer that occurs below 500 feet in the unconsolidated valley-fill sediments.

Shallow Aquifer - A shallow aquifer is arbitrarily defined as an aquifer that occurs in the upper 500 feet of unconsolidated valley-fill sediments.

Unconfined Aquifer - (Water-table aquifer) An aquifer that has a free water table which is not confined under pressure beneath relatively impermeable stratum.

ARTESIAN - An adjective referring to ground water confined under hydrostatic pressure.

DRAWDOWN - The distance by which the level of a reservoir is lowered by the withdrawal of water.

EXCLUDED WATER SUPPLY WELL AREA - Area not recommended for surface or ground water appropriation and development for environmental cultural and hydrogeological reasons.

EVAPOTRANSPIRATION - The process by which ground water becomes atmospheric water either by evaporation from a surface or transpiration by plants. No effort is made to distinguish between the two.

HYDRAULIC CONDUCTIVITY - The amount of water flowing through a unit area of aquifer normal to a unit gradient. It is a measure of the ease with which a material transmits water.

HYDROSTATIC PRESSURE - The pressure exerted by the water at any given point in a body of water at rest. The hydrostatic pressure of ground water is generally due to the weight of water at higher levels in the zone of saturation.

LACUSTRINE - Pertaining to, produced by, or formed in a lake or lakes.

PERENNIAL YIELD - The amount of water that can be withdrawn on a continuous basis without causing an undesirable result.

The term "undesirable result" is not defined, but may include intrusion of water of undesirable quality, reduction of head below an economic pumping level, or environmental effects such as destruction of marshy wildlife habitat or destruction of useful phreatophytes. Perennial yield must be less than the long-term average recharge, but other than that, generalizations cannot be made. Perennial yield cannot be computed until a management decision has been made on the definition of an undesirable result. Perennial yield in this report refers to state and federal estimates. These estimates are not accompanied by a quantification or definition of undesirable effects.

PHREATOPHYTE - A plant which takes water directly from the capillary fringe or water table. In the MX siting area, these are primarily greasewood, rabbitbrush, saltgrass, and pickleweed.

POINT OF DIVERSION - Point at which water is diverted for other use from surface water flow or from ground-water flow system.

POORLY SORTED - Consisting of particles of many sizes mixed together in an unsystematic manner.

POTENTIOMETRIC SURFACE - An imaginary surface representing the total head of water in an aquifer. It is the level at which water will stand in a properly constructed well. Ground water always flows from higher to lower potential and perpendicular to contours on the potentiometric surface.

PRIMARY WATER SUPPLY AREA - Alluvial fan deposits consisting of debris flow and water-laid alluvium considered of good hydraulic characteristics and appreciable permeability.

REVERSE OSMOSIS - Reversal in direction of the spontaneous flow through semi-permeable material such as clay or shale caused by reversal in electrochemical or hydraulic potential.

SECONDARY WATER SUPPLY AREA - Area of playa and lacustrine deposits occurring in active or inactive playas in older lake beds and abandoned shorelines having low permeability and limited water-yielding capability.

SPECIFIC CAPACITY - The rate of discharge of a water well per unit of drawdown, commonly expressed in gallons per minute per foot.

<u>SPECIFIC YIELD</u> - The volume of water which will drain from a saturated unit volume of an unconfined aquifer under the influence of gravity. Expressed as a ratio or percentage.

<u>STORAGE</u> - The volume of water recoverable from the aquifer under the influence of gravity.

<u>STORAGE COEFFICIENT</u> - The amount of water added to or removed from storage per unit of surface area of a confined aquifer per unit of change in head normal to that surface. Expressed as a decimal ratio.

<u>STORATIVITY</u> - A generalized term for storage coefficient and/or specific yield.

<u>TRANSMISSIVITY</u> - The amount of water flowing through a unit width of an aquifer in response to a unit gradient. It is a measure of the ability of an aquifer to transmit water. It is numerically equal to the conductivity times the aquifer thickness.

<u>WELL-SORTED</u> - Consisting of particles all having approximately the same size.

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